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UNIVERSITY COLLEGE OF WALES,
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WELSH PLANT BREEDING STATION.

Seasonal Productivity of Herbage Grasses,
by R. G. Stapledon, M.A.

The Nutritive Value of Grasses as shown by their Chemical Composition, by T. W. Fagan, M.A., and H. Trefor Jones, B.Sc.

Productivity of Different Strains and Nationalities of Red Clover, by R. D. Williams, B.Sc.

A Note on Subterranean Clover,
by R. D. Williams, B.Sc., and W. Davies, B.Sc.

Grassland and the Grazing Animal,
by R. G. Stapledon, M.A., T. W. Fagan, M.A., and R. D. Williams, B.Sc.

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Prefatory Note.

It has been found necessary, in order to arrive at definite and reliable conclusions as to the precise attributes of grasses which chiefly influence their economic value, to extend and continue the preliminary investigations that were initiated in 1919. The actual processes entailed in connection with breeding work with herbage plants are so laborious and involved that it is doubly important to endeavour at the outset to ascertain the most promising directions in which improvement may be expected to be achieved. The value of herbage plants so largely depending on their productiveness throughout the season, it has seemed desirable to concentrate chiefly on this aspect of the problem.

Thanks to the co-operation of Mr. Fagan, the Advisory Chemist to the Department of Agriculture, it has been possible to investigate the seasonal productivity of grasses from the point of view of chemical composition as well as merely of yield.

In the first article results obtained over the four year period (1920-23) in respect of yield and the influences affecting yield, in relation to different species, nationalities and strains of grasses have been presented and discussed. In the second article, Mr. Fagan, M.A., and his colleague, Mr. H. Trefor Jones, B.Sc., have supplemented the yield data by important chemical evidence based largely on seasonal cuts. In the third article, Red Clover is dealt with on lines similar to the grasses. In a further article the evidence brought forward in each of the papers concerned with detailed results is briefly discussed in relation to the grazing animal. A short note on Subterranean Clover concludes the bulletin.

The work conducted in connection with the present reports has entailed a vast amount of separate cuttings, weighings and separations. Thanks are due to Miss Grice, who was responsible for all the stem and leaf analyses and dry weight determinations (other than those connected with the chemical investigations) and for all the cuttings on single plants. Thanks are also due to Mr. Watkins, who was responsible for all the cuttings and weighings on drills and beds at the gardens. The preparation of the graphs has been undertaken by Mr. Beddows, B.Sc., a post-graduate student of the College, who has also assisted with some of the tables, and to whom thanks are likewise due. Grateful acknowledgment is made to Miss R. Jones, B.A., who has rendered invaluable assistance in connection with Scandinavian literature.

The Station is indebted to Dr. Abraham Thomas, of Aberystwyth, who, as in past seasons, has kindly provided the necessary meteorological data.

In conclusion, grateful acknowledgment is made to Messrs. Sutton and Sons, of Reading, who very kindly presented the Station with most of the lots of commercial seed used in connection with the trials under review, and to Messrs. McGill and Smith, of Ayr, who also presented certain lots of seed.

R. G. STAPLEDON.

Agricultural Buildings,
Aberystwyth,

June, 1924.

The Seasonal Productivity of Herbage Grasses with particular reference to the Influence of different systems of Cutting on Indigenous and Non-Indigenous Strains respectively.*

by

R. G. STAPLEDON, M.A.

Introduction.

The preliminary investigations with herbage plants previously reported dealt with results obtained in 1920 and 1921, and it was shown that the unusually dry growing season of the latter year rendered it necessary to make certain reservations with reference to some of the conclusions which the data then obtained would seem to have justified. For example it was evident that the indigenous strains of the several species on the average proved themselves more tolerant to the drought than their commercial counterparts, and were thus from the comparative point of view favoured by the prevailing conditions.

In the present article it is proposed only to deal with the small scale trials conducted with single plants, and with small plots consisting of sown drills, rows of propagants and tiller beds, many of which were started in 1920 and 1921, and which owing to the limitations of space and the development of other investigations have now to be discontinued. It is convenient to dispose of these trials at this juncture, since their completion marks the termination of a phase of the work in progress, and as far as the experience gained renders it necessary they are being replaced by trials bearing on the same problems, but conducted on a field scale or at all events under conditions more nearly approaching those of ordinary swards.

In order to elucidate grassland problems it is, however, essential to study individual grasses, and it is idle to argue that results are necessarily valueless or actively misleading if not obtained under conditions to which the agricultural mind is accustomed.

It is particularly difficult to conduct critical investigations with single species or strains of grasses or of clovers in sown broadcast or closely drilled

* Being an extension of a paper read at the December (1923) Meeting of the Agricultural Education Association.

plots, because it becomes absolutely impossible to eliminate all weeds—this is a difficulty which may be overcome if only yields are required, when the weeds may be removed from properly taken samples and the weights adjusted accordingly. If it is desired to investigate such matters as the relation of stem to leaf throughout the growing season, and to do so under different systems of cutting; to study the relation of different systems of cutting to root and tiller development, resort must necessarily be made to more artificial methods of culture.

Under field conditions it is admittedly a difficult matter to study the precise effect of grazing animals on swards, and yet this is obviously the fundamental starting point to a proper appreciation of the elements which constitute the grassland problem. An attempt can, however, be made to approach grazing conditions by adopting various systems of more or less frequent cutting. It is a matter of common knowledge that close grazing makes for an intensely leafy sward—frequent cutting has the same effect, so that it appears safe to assume that in many respects the grazing animal and the shears are likely to have the same qualitative if not the same quantitative effect on herbage plants.

It is with such problems as the above that it is proposed here chiefly to deal, special regard will, however, be paid to individual species and to the comparative behaviour of different nationalities and strains of the species under review.

I.—Material and Methods.

A.—Species and Strains. Most of the critical work relative to the problems to be considered has been conducted with Cocksfoot, other species such as Rye Grass, Tall Oat Grass, Tall Fescue and Vernal Grass have, however, also been employed. It is beyond the scope of the present report to deal with the work in progress relative to the morphological characteristics of the various strains of these species, and with the exception of Cocksfoot, distinction will only be made between indigenous and non-indigenous.

In the case of Cocksfoot, the following nationalities and strains will frequently be considered separately and as such :—(1) Danish and U.S.A., since the differences between these are not striking in respect of the characteristics under consideration, average results for the two nationalities together are given in all cases : (2) French, (3) New Zealand and (4) Indigenous, which are dealt with under three aggregate strains (*a*) "Dense-Pasture," (*b*) "Open," including both hay and pasture types and (*c*) "Tussock"; this strain has not been previously described, the individual plants differ from "dense-pasture" with which they were formerly included in forming larger "clumps" with longer radical leaves. The plants are not as dense as "dense-pasture"* very early in the spring, but as the season advances they become exceedingly dense. The plants are taller than "dense-pasture" and the majority are rather of a hay than a pasture type. In the case of some of the trials "dense-pasture," "open" and "tussocks" have been averaged and the results given simply as indigenous.†

B.—Conduct of Trials. A large number of separate trials have contributed to the results available, and since the data to be considered are very considerable

* See (32) Cocksfoot, p. 51—59.

† This has been done when the number of lots of each has not been sufficiently large to give reliable separate results.

it will not in all cases be practicable to present detailed tables, and in view of the fact that the yield results are from the nature of the trials not convertible into pounds or cwts. per acre, these in many instances will only be expressed proportionately to a standard.

It will, therefore, be necessary in every case to refer to the Station Number of the experiment from which data have been drawn, complete tables of course being filed with every experiment. Frequently also data are drawn from several trials when discussing a particular problem, reference will always be given to the trials involved.

It will therefore be convenient to give hereunder brief particulars of the chief trials contributing to the results, and so obviate the necessity of burdening the body of the paper with the necessary details.

(1) SOWN DRILLS. *B.1, Nurseries and B.14 Terraces: Cocksfoot.* These consisted of sown drills each 2 feet apart and 52 inches long, four drills substituting a bed. B.1 was sown on July 14th, 1919, and B.14 in the spring of 1920. B.1 contained 24 beds representing 24 different lots of seed of four nationalities, the lots were not duplicated, but several beds were devoted to each nationality. B.14 contained 23 beds representing as many lots of seed of the same nationalities as B.1, again the lots as such were not duplicated.

B.36, Perennial Rye Grass, B.21, Timothy, B.32 and B.62, I. Meadow Foxtail, and B.29, I. Tall Oat Grass: Terraces. All the above were sown at the same time as, and in a similar manner to, B.14 in the spring of 1920. The lots as such were not duplicated, but each nationality was represented by several lots, indigenous and non-indigenous strains were included in each trial. The number of lots for the different species was as follows: Perennial Rye Grass 17, Timothy 11, Meadow Foxtail 6, and Tall Oat Grass 4. In the case of all the above sown beds certain of the drills were used for hay *cum* aftermath cuts and others for continuous pasture cuts.

(2) BROADCAST PLOTS. *E.30, II. Brick Field.* This consisted of plots sown with the following mixture in lb., per acre:—Perennial Rye Grass 12, Cocksfoot 8, and English Late Flowering Red Clover 4.2. The plots were 1/400 of an acre and replicated three times for each cutting treatment. Pasture cuts were made with a garden mowing machine.

(3) OLD ESTABLISHED SWARD. *E.30, III. Quarry Field.* The area having been sown out twelve years previously (in 1911) had become a fairly typical permanent grass field for the soil type and district. Long narrow plots each 1/100 acre and replicated four times for each treatment were employed. Pasture cuts were made with a garden mowing machine. The previous management of the field had been 1912 hay; 1913-16 pasture; 1917-22 hay.

(4) ROWS OF CLOSELY SPACED PROPAGANTS. *B.60, The Knoll: Cocksfoot.* This experiment was devised with a view to obviating the irregular stands that are likely to result from seeding. Plants in a first harvest year were dug up and broken into large propagants of equal size and these were planted out in 10 ft. rows, the rows 1 ft. 6 in. apart, with 15 propagants to each row. Six rows constituted a bed and each bed was replicated four times. The beds were set out in the autumn of 1921, and throughout the whole of the

duration of the trial the rows were kept horse and hand hoed so that weeds were reduced to negligible significance. The propagants established themselves excellently, and by the spring of 1922 had filled up well in the rows. It is probable, however, that this method of culture involving continual hoeing slightly favoured the indigenous plants, but in the main Cocksfoot as a whole withstood the conditions decidedly well and far better than other species.

The beds were used for quantitative data in respect of hay *cum* aftermath, pasture and seed production, never less than two rows constituting a unit, and each unit being at least duplicated and in most cases replicated four times. Eighteen lots of indigenous, ten of Danish *cum* U.S.A., one of French and one of New Zealand were included in the trial.

B.75. The Knoll: Perennial Rye Grass. This trial was set up and used in a precisely similar manner to B.60, and consisted of four indigenous and five commercial lots. Perennial Rye Grass, however, did not withstand the continual hoeing at all well, and it was very soon apparent that the best lots of indigenous were considerably more tolerant to the conditions than the non-indigenous.

B.76. The Knoll: Timothy; B.77. Tall Oat Grass. These trials were also similar as to setting up and replication to B.60 and consisted, for Timothy, of three indigenous and nine commercial lots; and for Tall Oat Grass of three indigenous and one commercial lot. Timothy withstood the conditions fairly well, but unfortunately during 1922 the lots were differentially attacked by *Puccinia Phlei-pratensis* E. *et* H., which upset the results obtained in that year, those of 1923, however, being much more satisfactory. French Tall Oat Grass suffered from the hoeing decidedly more than indigenous.

(5) TILLER ROWS. *B.29, II. Terraces: Tall Oat Grass; B.62, II. Meadow Foxtail.* Instead of large propagants being used the plants were broken down to quite small units of about three or four tillers each, and these were planted in narrow beds 20 ft. long and 6 in. wide. The tillers were planted in the autumn of 1922, the spacing being 3 in. × 3 in., and by the spring of 1923 quite excellent little swards had developed. Two indigenous and one non-indigenous lots of Tall Oat Grass and six indigenous lots of Meadow Foxtail were employed. The lots were not replicated.

(6) TILLER BEDS. *B.93, Terraces: 14 Species of Grasses.* As in B. 29, II., units consisting of plants broken down to two or three tillers were employed. In most cases these were obtained from plants sown early in 1921 in boxes and planted out in nursery lines—the plants being lifted and broken down in the late autumn and early winter of that year when the tillers were dibbled at about 3 in. apart into the permanent beds. The beds were 9 ft. by 4 ft. and 620 tiller units were devoted to each bed.

In the case of these small units 1921 was a very unfavourable year for setting up the experiment, and, moreover, the planting was not completed until the middle of December. Fairly good swards in many cases had apparently been developed by May of 1922, and it was decided to start the schemes of cutting. Two areas of a yard square were marked off within each bed, thus leaving margins. One area was cut on a pasture cut basis and the other only for hay and aftermath. By the end of the season it was evident that the beds had

not been sufficiently well established to stand the pasture cutting, consequently in 1923 the procedure was reversed, the areas previously devoted to hay *cum* aftermath being used for pasture and the previous pasture areas for hay. Owing to the rather poor establishment the yields from these beds in both 1922 and 1923 were decidedly below the average, and considerable difficulty was experienced in keeping down weeds in the pasture portions, this was, however, satisfactorily achieved in the case of the larger grasses, while the hay was easily freed from weeds before weighing. The Meadow Grass beds (except *Poa serotina*) had to be discarded, *P. pratensis* on account of excess of White Clover having come in and *P. trivialis* on account of very poor establishment. The pasture yields, more particularly in 1923 in the case of Crested Dog's Tail, Fine Leaved Fescues, commercial Tall Oat Grass, Meadow Foxtail and Sweet Vernal Grass, were probably influenced to an appreciable extent by weeds, but it is quite safe to assume that this source of error will have been far less than could possibly have been assured under any system of maintaining broadcast field plots. The trial consisted of 147 beds, and except in the case of *Poa serotina*, indigenous and non-indigenous lots of each species were included—the lots were set out in duplicated beds.

(7) SINGLE PLANTS. *B.57, Terraces*: *Cocksfoot.* This trial consisted of 156 plants of indigenous, 114 of Danish *cum* U.S.A., and 32 of French. The plants were set out in 1920, 2ft. 2 in. apart.

B.56, I. and II., Knoll: *Cocksfoot.* (I.) Only indigenous were included in this trial, each plant was broken into about 20 propagants. The propagants were set out in plant rows 2 ft. 2 in. apart and 1 ft. 6 in. in the rows. Four propagants were used as the unit for quantitative data. Number of plants and therefore of plant rows 220. The propagants were set out in the autumn of 1921, and by May, 1922, had made large separate plants. (II.) In the autumn of 1921 selected plants were taken from B.57, and broken into propagants and set out in plant rows similarly to part I. Three propagants were used as the unit for quantitative data, cutting was, however, deferred until 1923, when each propagant had become as large as the original mother plant. The number of plants and of plant rows was in this case 33 indigenous, 18 Danish *cum* U.S.A., and 9 French, of which 11 indigenous, 6 Danish *cum* U.S.A., and 2 French were used for a special sub-experiment.

B.108, Terraces: *Cocksfoot.* This trial consisted of single plants set out from nursery lines in spaced rows. Since the object of the experiment was to conduct critical determinations relative to the effect of cutting seldom and often on both yield and stem to leaf ratio—the plants were carefully matched up in groups for the several cutting treatments. (I.), set up in 1920 for cutting in 1921 and subsequent years. Eighty plants representing indigenous Danish *cum* U.S.A., and French. (II.), set up in 1921 for cutting in 1922 and subsequent years. Forty-six plants representing indigenous, New Zealand, Danish *cum* U.S.A., and French. (III.), set up in 1922 for cutting in 1923. Twenty plants, all indigenous. In this case the necessary groups were arranged for by breaking up the large and well established plants into the requisite number of propagants.

B.70, I. and II., Nurseries, Knoll: *Tall Fescue.* These trials were set up on the same plan as B.56. Part I. consisted of 9 propagants in each case

and Part II. of about 20. Two or three propagants were used as the unit for quantitative data. Dutch, New Zealand and indigenous lots were employed. Number of lots 10.

In addition to the above the following trials all set up in the Terraces have been drawn upon to a limited extent. In all cases the plants have been broken into fairly large propagants and set out on the plant row basis. The various systems of cutting have been performed on different groups of propagants of the same plants. In the statement hereunder only those lots (in the first instance each lot was a single plant) contributing to the trials in question which have been brought into the cutting schemes here considered are included.

*B.*69 : *Sweet Vernal Grass.* Four lots set up in 1921 for cutting in 1922 and again in 1923, cutting unit three propagants per lot for each system.

*B.*91 *and B.* 111 : *Perennial Rye Grass.* The former, consisting of 46 lots set up in 1921 for cutting in 1922, and the latter of 50 set up in 1922 for cutting in 1923, in the case of this and the following trials the cutting unit for each system consisted of two propagants per lot.

*B.*92 : *Italian Rye Grass.* Fourteen lots set up in 1921 for cutting in 1922.

*B.*98 *and B.*113 : *Timothy.* The former, consisting of 21 lots set up in 1921 for cutting in 1922, and the latter of 51 lots set up in 1922 for cutting in 1923.

*B.*92 : *Fine Leaved Fescues.* Thirty-six lots set up in 1922 for cutting in 1923.

*B.*97 : *Smooth Stalked Meadow Grass.* Nineteen lots set up in 1922 for cutting in 1923.

It will be evident that when different systems of cutting are in effect performed on the same plant by resorting to the propagant method, that the results are by that much freed from what may be a serious source of error due to different plot units consisting of different proportions of the various strains, or at all events of different types which may have contributed to a lot—greater uniformity between the plot units being attainable by the propagant method than by endeavouring to match up plants or the taking of any other conceivable precautions. It should therefore be emphasised that perennial grasses afford admirable material upon which to obtain critical quantitative data, for it thus becomes possible to use not merely a definite variety, not merely a definite pure line, but actually one and the same plant or the same group of single plants for all the treatments desired. It should be added, that it is surprising how uniform in size and growth the propagants become when established, so that with an excess number put out in the plant rows, from which to select and "match up" a really quite remarkable degree of plot uniformity may be attained to by this procedure.

Owing to the fact that the soils both at the farm and the gardens are typical of the district and are therefore lacking in phosphates it has been the practice of the Station to give a generous initial dressing of basic slag or mineral phosphates (equivalent to 6-8 cwts. per acre of high grade slag) as each new area has been brought under plots. At the gardens superphosphate at about the

rate of 2 cwt. per acre was applied in April, 1920; this was followed by basic slag (3 cwt. per acre) in February, 1921, and by a light dressing of Narau phosphate in March, 1922.

C.—Methods of Cutting. Except in the case of a part of B.108 III., when the cuts were made at a level of 2 in. above the ground—the cuts have been taken as far as is possible hard to ground level, this is comparatively easy of achievement when plants are repeatedly cut, but is impossible when large plants are cut less often. In the latter case the "stools" become somewhat convex, and it is only practicable to clip off the herbage hard against the dry base.

With care there is but little risk of dropping or losing any appreciable amount of the herbage, and with practice the cutting can be efficiently and rapidly performed. A small sickle followed by sheep shears deals best with the larger cuts, while an ordinary knife or sheep shears are most convenient for the small cuts, scissors being best for the smallest cuts. Horticultural despatch (=chip) baskets of standard sizes have been found the cheapest and most satisfactory receptacles for carrying the clippings from the plots to the field laboratory, in the case of the smaller cuts the baskets are lined with paper.

It should be emphasised that the effects of a system of oft-repeated cutting can not be regarded as identical to the influence of even heavy grazing—and it would seem probable that the plants would be more rapidly exhausted when constantly cut back than when grazed. Under the former treatment practically all the stems and leaves are removed at one operation, thus depriving the plants temporarily of nearly the whole of their synthetic organs. Animals on the other hand rarely graze sufficiently close—or at all events but seldom during the season—to remove all the stems and leaves, and thus such stems and leaves as are left ungrazed would presumably enable the plants to recover more rapidly than when frequently and wholly deprived of their aerial resources. Under a system of cutting also everything is removed, while under grazing much is returned. It will be shown, however, that the results of frequent cutting are so striking that it can hardly be doubted that grazing must exercise similar influences, and even if these are very greatly minimized under field conditions there would yet remain ample room for different methods of managing grass fields—alternating meadow conditions with pasture; using fields wholly as the one or the other; varied systems of grazing, heavy or light, with one class of stock alone or with mixed stock; constant or alternate grazing and the like, particularly when the same general methods are continued year after year—to stamp themselves in an unmistakeable manner on the composition, productivity and quality of the herbage.

D.—Systems of Cutting. Various schemes of cutting have been adopted, and since it will be shown that the date at which cutting is started is of supreme significance it will be convenient to group the schemes into four different main classes, and to give to each class a definite title, by means of which they will severally be referred to throughout the body of the paper. The classes are as follows :—

(1) HAY AND AFTERMATH. This of course consists of two cuts, the first being made as nearly as possible when the subjects are in full flower, and the second at no definite interval thereafter, but usually when a second crop

of more or less well developed flowering shoots have been developed, or failing such a second crop when growth has again attained to considerable luxuriance.

(2) HAY AND MORE THAN ONE AFTERMATH CUT. This may be conveniently referred to as " hay and aftermaths," and consists of taking a hay cut rather on the early side, but in no case before flowering has actually commenced, this is followed by a first aftermath cut at no definite interval, but usually when flowering or at least advanced stem development is again apparent, the second aftermath cut would again be taken at no definite interval but when the plants were ready, and similarly with a third aftermath cut if such were possible, and again if possible with a fourth. This is, of course, the farm practice adopted with Lucerne which aims at taking as many cuts as possible when the plants are in a hay condition. Sometimes a final aftermath cut may be taken, it may be a third or fourth, or in extreme cases (*e.g.*, with such a plant as Lucerne) even a fifth cut, which will usually in no sense of the word constitute a stemmy and hay-like product, but which will be short and leafy—when such a cut terminates a sequence of genuine aftermath cuts it must of course be regarded as one of the sequence. In the present connection the maximum of cuts coming under this category has been three, namely, a hay and two aftermath cuts, when the last cut has always been predominantly leafy.

(3) HAY AND AFTER-CUTS. This consists of taking a hay cut at the proper time, but instead of following it up with one or more aftermath cuts when the plants are again approaching to a hay condition, to take a series of cuts at fixed, say 10, 14 or 20 day intervals, until the end of the growing season. Thus say four cuts might consist of a hay and three aftermath cuts or of hay and three after cuts, and it will be shown that the distinction is a real and important one.

(4) PASTURE CUTS. The essence of a system of pasture cuts as understood in this paper is that the cuts shall follow each other at regular intervals (say 10, 14, 20, 30 or 40 days), and that the first cut be necessarily taken before or at all events not appreciably after the plants have fully headed, that is to say some time before there are any indications of flowering (stigma or anther exsertion). In the present investigations no system of pasture cuts consisting of less than four cuts has been adopted, and usually the number has varied between six to seventeen. Pasture cuts fall into three natural and important sub-classes according to the stage of the plant's growth when the cuts are initiated. We have :—

(*a*) *Zenith Period Initiation.** This implies cuts initiated when the plants have reached or nearly reached the heading stage, and before they have begun to flower. Such cuts have usually been started early in May.

* It was shown in a previous bulletin (see (32), p. 21—34), that the herbage year naturally falls into a number of clearly defined periods. The periods overlap to some extent, and the range of dates proper to each period will of course vary from district to district, and will be determined to no inconsiderable extent by the nature of the species which predominate in the herbage. Experience now gained over the four years 1920—23 would suggest a slightly different date range than that specified in the earlier publication. The periods with the amended date ranges are as follows :—" Dead Period " (towards the end of November to the end of February or early March) ; " Awakening Period " (early to middle of March to about end of April), this period covers the first growth of spring up to " heading stage " ; " Zenith Period " (late April—early May until about the end of June), this period covers the heading and flowering stages of the plots ; " Gradually Waning Period " (towards end of June—middle of July to early-middle October) ; " Rapidly Waning Period " (about middle October to end of November).

(*b*) *Awakening Period Initiation.* Implies cuts started when the plants have begun to make some appreciable though almost entirely leafy growth early in the spring—such cuts have been started in the middle of March or early April.

(*c*) *Dead Period Initiation.* Implies cuts started when the plants are still in their semi-dormant winter stage—such cuts have been initiated in November, January and February.

It is, of course, very important with a view to accurately comparing results from different systems (= number of cuts in the incremental series) of pasture or after-cuts, particularly in the case of those systems started in the same initiation period, that it should be arranged to commence cutting on them all at practically the same date, and also to end at the same date, and the more intervening dates common to all systems, no matter when initiated, the better. Thus a carefully thought out schedule has to be arranged and adhered to as closely as circumstances will permit.

E.—Weighing. When a programme involving over two thousand separate cuttings and weighings is being worked through during the growing season, it is obvious that weighings must be reduced as far as possible as also docketing, drying and storing. For this reason air drying to a condition of hay is not practicable, and resort must be made to the more rapid and more accurate method of obtaining absolute or relative dry weights or reliance must be placed on green weights alone. For many comparative purposes green weights would seem to be quite satisfactory provided that the cuttings can be made under conditions of perfect dryness.

In the case of a few-cut schedule it is not of much significance if an actual cutting date departs a few days one side or the other from the scheduled date ; when the cutting is oft-repeated such a departure would, however, both upset the weights and disorganise the schedule. Green weights have of necessity been largely relied upon in connection with the present investigations, and it has been found that cuttings can often be satisfactorily performed during a day of early morning rain or heavy dew by lightly brushing the plants to be cut some hours before it is hoped to cut them. Departure from schedule has always been regarded as a lesser evil than cutting under obviously unsatisfactory conditions.

When obtaining dry weights time has not permitted of drying to a constant weight, or of milling the herbage. The herbage has been dried for about 60 hours in ovens at 95 °C.—98 °C., check trials having shown that for comparative purposes this procedure is sufficiently satisfactory.

F.—Stem and Leaf Determinations. It is a relatively simple, although an exceedingly laborious matter, to make accurate stem and leaf analyses in a sample of hay—the leaves, including blades and sheaths, can be stripped off the stems. This is less easy in the case of aftermath, while under a system of oft-repeated cutting the amount of stem will be negligible except in the few cuts falling in the zenith period. An examination of the produce from a system of repeated cuts taken from different species of grasses or from different strains of the same species shows, however, very decided differences in the ratio of blade to the closely adhering sheaths which support the blades, while an examination

of any closely grazed pasture will reveal the fact that it is the blades and not the adhering sheaths that are chiefly taken by the browsing animals. It is also to be noted that blades tend to be greener, and of a somewhat different texture to the adhering sheaths. It was thought, therefore, that "blade" rather than leaf (= blade and sheath) should be taken as the "leaf" unit to form the basis of analyses required to cover comparisons between hay, aftermath and pasture cuts, the general assumption being that from the fodder value point of view blade as such (both qualitatively and quantitatively considered) might be a decisive factor influencing the comparative value of herbage grasses. All analyses (hay, aftermath and pasture) alike were therefore made on the same simple plan. The blades were nipped off at the ligule and were regarded as "leaf," everything else—sheaths, stems proper and inflorescences were placed together and regarded as "stem." Thus on strict morphological grounds "leaf" as referred to in this and subsequent papers dealing with grasses is to be understood as blade only and "stem" as stem proper plus sheath; on oft-repeated pasture cuts the comparison becoming practically that between blades as such and sheaths as such.

The procedure adopted was to cut a few plant units at a time to take these to the field laboratory and perform the "stem" and "leaf" separations as quickly as possible. The separations having been made green weights were obtained and in most cases dry weights (as previously defined) were subsequently ascertained. It was thus possible to arrive at a comparative moisture content of green "stem" and green "leaf" respectively—this could not of course be an accurate figure since the samples were losing water all the time the "stem" and "leaf" separations were in progress, and moreover the larger the sample to be separated the longer the time that must necessarily elapse to complete the separations, the rapidity of loss also being influenced by the prevailing conditions on each of the cutting dates constituting a system.

When dry weights as well as green weights have been obtained on produce which has not been subjected to stem and leaf analysis, in most cases, less than five minutes has been allowed to elapse between the cutting of the plants and the weighing of the green produce. Thus provided the cuttings have been performed under dry conditions, quite accurate dry matter determinations have been possible on these unseparated bulks.

II.—The Problems Involved—Review.

When contrasting the influences of different systems of cutting it is necessary to pay due regard to the climatic conditions obtaining and to consider the question from three distinct points of view, namely:—(1) the relation of the different systems to the gross bulk of produce which may be obtained during the cutting season, (2) the relation of the different systems to the quality of the herbage produced under their influence during the cutting season, and (3) the relation of the different systems to the quality and quantity of the herbage developed during the season immediately following the various systems of cutting and during subsequent seasons.

(1) *Comparison between the gross yield from Pastures and Meadows.* It has long been realised in a general way that fields treated as meadows will produce heavier bulks of produce per annum than those devoted to grazing—this view

was quite definitely expressed by Sir John Sinclair* (24) early in the nineteenth century. In 1894 Crozier (5) working with Cocksfoot at Michigan showed that plots cut respectively four and six times from the commencement of the growing season up to the time of hay cutting, hardly produced half the bulk of produce given in terms of hay on plots from which the hay cut was the first cut of the season.

More detailed trials were conducted by Lindhard (15) in Denmark in 1907 on permanent grass, and by Ellett and Carrier (7) on blue grass pastures in Virginia during 1908 and subsequent years.

The results reported by the above authors together with data obtained on swards at Aberystwyth (1923) are set out comparatively (with the weight given by the greater number of cuts expressed as a percentage of that given by the least in each case) in Table I. hereunder. It will be noted from the table that in each case a progressive falling off in yield shows itself as the number of cuts is increased, while the blue grass figures suggest that under a system of frequent pasture cuts the yield does not drop proportionately when the number of cuts is increased beyond a certain maximum. The above results refer to ordinary sward conditions and will have been influenced therefore not only by the varied yielding abilities of the different species in relation to the treatments, but also by the effects of altered conditions on the aggressiveness of the several contributing species. These influences must be taken into account particularly in the case of Ellett and Carrier's results, which have been based on averages obtained over a four year period. Thus the botanical composition of the produce given under a system of few cuts is likely to be different to that given under a more drastic system ; Ellett and Carrier for instance, remarking that on the plots frequently clipped Blue Grass (*Poa pratensis*), Red Top (*Agrostis spp.*), and White Clover predominated, while on those cut but seldom plants like Wild Carrot and Paspalums became abundant. In the case of B. 93 (Aberystwyth) weeds contributed appreciably more to the produce from the many than from the few cuts, and this would largely account for the relatively small difference between the yields given by the two systems of cutting in this instance.†

The above results are, however, interesting, just because they represent ordinary swards and seem conclusively to prove that meadows yield very considerably greater bulks of herbage per annum than pastures. They show, however, the absolute necessity of conducting critical work with separate species in pure cultures kept absolutely free from weeds.

(2) *Growth Habit: The Ratio of Leaf to Stem.* The importance of the growth habit assumed by different species and strains under varied conditions in relation to quality has been emphasised by numerous investigators, notably by Sinclair (25), 1824 ; Hall and Russell (11), 1912 ; Lindhard (15), 1912 ; and Osvald (20), 1919. In particular, the ratio of leaf to stem has been shown to be of considerable significance. The influence of environmental factors and cultural methods on the stem to leaf ratio would not, however, appear to have received the attention it deserves, more particularly with reference to the

* See footnote on p. 161.

† Exaggerated in this case, because the weeds were removed absolutely from the hay plots and only partially from the pasture plots.

TABLE I.—*To compare the yields given by a hay cut or a hay cut and one aftermath cut with those from the aggregate produce of a number of pasture cuts.*

Place, sward type and authority.	Systems of cutting adopted at the several centres and yields as a percentage of the hay or hay *cum* aftermath yield.					Remarks.
On permanent blue grass pastures : Virginia, U.S.A. Ellet & Carrier (7).	Hay only	Cut every 30 days	Cut every 20 days.	Cut every 10 days.	Cut every 7 days.	Average results when treatment continued over a 4-year period. Air-dry substance.
	100	70	58	57	56	
Permanent grass : Dolly, Denmark, Lindhard (15).	Sum of hay and aftermath.	Three pasture cuts.	Four pasture cuts.			As ordinary hay.
	100	77	56			
Permanent grass : Aberystwyth, E. 30 III.	Sum of hay and aftermath.	Eight pasture cuts.				Green fodder.
	100	61				
Temporary ley in 1st harvest year : Aberystwyth, E. 30 II.	Sum of hay and aftermath.	Nine pasture cuts.				Green fodder.
	100	66				
Tiller beds : average of twelve grass species. Aberystwyth B. 93.	Sum of hay and aftermath.	Six pasture cuts.				Green fodder.
	100	83				

seasonal fluctuations normally exhibited by this ratio. Lindhard,* working with pure cultures of Cocksfoot and Tall Oat Grass, has, however, studied the matter in some detail from the seasonal point of view, but instead of making stem and leaf separations he divided the produce of his incremental cuts into (1) "stem shoots," being all shoots with which a portion of true stem was cut off, and "leaf shoots," being those shoots giving only leaves and leaf sheaths. He found in the case of both grasses that stem shoots were at their highest in the hay cut, being 80 per cent. for Cocksfoot and 100 per cent. for Tall Oat Grass. Under a system of six cuts (May 19th—October 15th) he obtained the following percentage results for the two grasses :—

	Cocksfoot.	*Tall Oat Grass.*
1st cut.	44 per cent. stem shoots.	94 per cent. stem shoots.
2nd ,,	32 ,, ,, ,, ,,	55 ,, ,, ,, ,,
3rd ,,	12 ,, ,, ,, ,,	93 ,, ,, ,, ,,
4th ,,	0 ,, ,, ,, ,,	93 ,, ,, ,, ,,
5th ,,	0 ,, ,, ,, ,,	93 ,, ,, ,, ,,
6th ,,	0 ,, ,, ,, ,,	58 ,, ,, ,, ,,

Lindhard's figures bring out a striking difference between the two grasses which, as he shows in detail, can be accounted for by the very different growth habits of the two species—incidentally his results suggest the production of a much more leafy all-through-the-season growth from Cocksfoot than from Tall Oat Grass. The relation of a high percentage of stem shoot to yield as such is also brought out by Lindhard's investigations, thus on the six cut system the yield at the first cut (May 19th) with a stem shoot contribution of 44 per cent. was practically three times as great as the second (June 5th) cut, with a stem shoot contribution of 32 per cent., while the yield from the sum of the first three cuts (May 19th—June 26th) each with a considerable or appreciable contribution from stem shoots was over three times as great as that from the sum of the last three cuts (July 25th—October 15th), consisting wholly of leaf shoots. In the case of Tall Oat Grass when the stem shoot contribution dropped to 55 per cent. (June 5th) the yield was but a seventh of that on May 19th with a leaf shoot contribution of 94 per cent.

(3) *Quality*. The question of quality from the chemical point of view is dealt with in detail in a separate paper; it may be remarked, however, that Lindhard's results are in general agreement with those of Ellett and Carrier as showing tha the amount of nitrogen harvested in the gross bulk taken from many cuts was actually as great as or even slightly greater than that taken from one or from two cuts, while although Lindhard did not make chemical analyses separately on stem and leaf shoots as such, and Ellett and Carrier made their analyses on non-separated bulks, the results could not have been possible unless leaf shoots (and therefore presumably leaves also) contained a higher percentage of nitrogen than stem shoots (and therefore presumably of stem also).

Sutton and Voelcker (28) investigated the relation of the nutritive value of hay compared to aftermath, when the hay was cut at five different dates, and showed that the earlier the hay was cut (provided the plants had attained to "heading" stage by the date of cutting) the more and better was the aggregate produce from the hay *cum* aftermath.

* *loc. cit.*

Osvald (20) working with hay from four year leys on peaty soil sown with various species and from two contrasting centres, as well as separating the produce into component species, divided each grass species as such into "barren" and "fertile" tillers, and conducted chemical analyses on these separately for each of the contributing grasses. This separation would not seem to have been quite equivalent to that of Lindhard, since with the fertile tillers would only be included such as of necessity bore inflorescences. Reference to Table XIV, p. 52, in a previous bulletin (32) shows, however, that a high proportion of barren to fertile tillers goes with a high ratio of leaf proper to stem proper, and thus the percentage of barren tillers affords a rough index as to the leafiness of a plant. A separation of hay on this basis would of course effectively divide the sample into two portions, one predominantly stemmy and the other predominantly leafy. It follows that Osvald's results, like those of Lindhard, bear very directly on the problems under discussion, and it is of interest to record that a critical examination of his data appears to justify his assertion that as a rule the differences chemically considered between the various species of grasses are not greater than the differences between the flowering stem and leaf shoot of one and the same species. He points out also that the ratio of flowering stem to leaf shoot varies very considerably for one and the same species according to conditions—that this is so has been abundantly confirmed at Aberystwyth by counts made on the same plants in different seasons and on propagants of the same plants growing at the farm and in the gardens. Osvald concludes that it is as important to know the flowering stem to leaf shoot ratio of the component grasses as it is to know the percentage contribution of each species as such to the hay. Eikeland (6) has given a very complete account of the chemical composition of the chief herbage plants of Norway and has compared "seeds" with meadow hay of various types—Norwegian, Swedish and German. He has also dealt with the influence of different dates of harvesting on the composition of the hay of a number of species. He has not, however, differentiated between "stem shoot" and "leaf shoot," but his data are of considerable interest as affording a comparison with the chemical analyses made at Aberystwyth on the several species of grasses in the hay stage (stem and leaf together).

(4) *The Influence of Meteorological Conditions on Yield.* The relation of rainfall to hay and aftermath yield for a number of grasses has been studied by Witte (29) in Sweden over the period 1910-21. He points out that good comparisons can only be made between trials conducted under generally similar conditions and from crops representing the same harvest year in all cases. These are of course difficult conditions to fulfil. From a critical examination of his data Witte concludes that the hay crop is most profoundly affected by the amount of rain falling between the date when the grasses commence growth in the spring (=the awakening period) and the date when the cut is taken. This view is also supported by extensive data presented by Rhodin (23). Timothy, which flowers later than other grasses, may thus be much benefited by rain falling, after the earlier grasses have been cut. Since different species of grasses start active growth at different dates and also have different flowering dates, and since the same species will not conform to the same dates in respect of either function in different years, it follows that the period of time during which rainfall appears to have the greatest influence varies over a fairly wide range.

Witte states that his trials (in Sweden) show that it may be for Cocksfoot as short as 53 days and as long as 75, and for Timothy as short as 67 and as long as 100.

Gilchrist (10) in his summary of the Cockle Park Experiments (1898-1905) shows, however, that soil temperature equally with rainfall must be regarded as a dominating influence affecting the yield of hay. Thus in 1901 when May "was remarkably *cold* and wet" the hay yields were very low, they were, however, at their lowest in 1905, when both the early summer and the preceding winter "were remarkably dry." The Cockle Park results also suggest that, hours of sunshine as such may exert a considerable influence, thus a relatively dry summer with little sunshine, may not be incompatible with high hay yields—1898 was such a year giving actually the highest hay results for the eight years under review.

With reference to aftermath Witte considers it to be highly probable that the amount of rain which falls immediately before and immediately after the first (= hay) cut exerts a very marked influence on the bulk of the aftermath cut.

It is difficult to compare hay yields from a first harvest year with those from subsequent years. Witte, however, shows from trials conducted over a ten year period that under ordinary circumstances, Cocksfoot, Timothy, and Tall Oat Grass when grown in pure plots tend to give their heaviest yields in the first harvest year, the yields falling progressively till by the third or fourth harvest year the yields are likely to be 20 per cent. to over 30 per cent. lower than those given in the first harvest year. This general rule of course does not apply to leys giving very poor yields during a first harvest year, due, say, to the influence of drought, while if a second dry year follows the first the yields in the third or fourth harvest years may be greater than that of the first.

III.—The influence of different systems of Cutting on the gross yield obtained during the season of Cutting and the effect of Meteorological Conditions on the yield as such.

A.—Hay and Aftermath. The relation of aftermath to increased yield over that given by hay alone is governed by a number of variable factors.

Results obtained from trials conducted with Cocksfoot over the four years 1920-23, are set out in detail in Table II., while the salient meteorological conditions during the growing season of each year are set out in Table III. The two trials, B.1 and B.14, were very similar, they consisted for the most part of the same lots and were set up in adjoining gardens of practically identical soil type. Thus the yields from these trials can as such be compared. B.60 was conducted on a different plan and at the farm, so that the yields can not be directly compared with B.1 and B.14. In preparing the meteorological data it has been assumed that April 13th represented the commencement of active growth in each year—so following Witte's plan the period of hay growth has been regarded as April 13th to date of cutting, and the aftermath period as commencing one week before the date of the hay cut.

Except in the case of 1920 (B.1) and 1921 (B.14) it is not possible to compare yields in each year from crops in the same harvest year—the results are, however, informing in several important directions.

Judged by the meteorological conditions (see Table III.) 1920 and 1923 would seem to have been far more favourable to hay production than either 1921 or 1922. It will be seen that the hay periods of 1921 and 1922 were remarkably similar, both being characterised by a very slight rainfall ; April

TABLE II.—*To compare the yields of hay and aftermath from the first with subsequent harvest years for the four harvest years 1920—23 for Cocksfoot in drills.*

Green weights per stated length of drill or row.

	B1., oz. per 52in. of drill.				B14., oz. per 52in. of drill.						B60., oz. per 20ft. of row.			
	Hay.				Hay.			Aftermath 1 cut.			Hay.		A'math 1 cut.	
	1920	1921	1922	1923	1921	1922	1923	1921	1922	1923	1922	1923	1922	1923
Indigenous agg.	45	18	26	44	31	37	43	25	17	23	233	249	116	89
,, Tussocks	—	—	—	—	36	38	53	24	16	33	280	318	149	128
,, Dense Pasture ..	—	—	—	—	33	42	40	27	12	21	210	208	99	74
,, Open	—	—	—	—	23	31	43	25	22	16	209	222	100	64
Danish *cum* U.S.A.	46	12	21	39	27	40	42	25	13	14	176	182	82	58
French	42	7	10	21	17	30	30	13	11	12	141	158	58	45
Average of Indigenous agg. and Danish *cum* U.S.A.	45.5	15.0	23.5	41.5	29.0	38.5	42.5	25.0	15.0	18.5	204.5	215.5	99.0	73.5

	B14.			B60.	
	1921	1922	1923	1922	1923
Sum of hay and aftermath for average of Indigenous agg. and Danish *cum* U.S.A.	54.0	53.5	61.0	252.7	289.0

TABLE III.—*To show the salient meteorological conditions for the growing seasons of the four years* 1920—23.

The periods associated with hay production and aftermath production are treated separately.

Particulars.	1920	1921		1922		1923	
	Hay period. 13/4—30/6	Hay period. 13/4—30/6	Aftermath period. 23/6—28/9	Hay period. 13/4—18/6	Aftermath period. 11/6—4/9	Hay period. 13/4—22/6	Aftermath period. 15/6—22/9
No. of days for growth	79	79	97	67	84	71	100
No. of rainy days in growth period	53	35	41	27	31	41	62
Total rain in growth period in inches	10.51	3.85	9.58	3.24	8.72	6.13	12.54
Average rain per day (not per rainy day) in growth period, in inches	.13	.05	.09	.05	.10	.08	.12

		1920		1921		1922		1923	
		Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
Average maximum and minimum daily temperatures F° for the six months April—September.	April ..	50.5	43.1	53.4	41.1	48.5	36.6	52.8	42.0
	May ..	57.4	47.3	56.9	45.7	58.6	47.2	54.1	44.2
	June ..	62.6	52.0	64.0	51.1	61.1	50.8	57.6	50.2
	July ..	—	—	70.4	57.0	60.3	52.2	65.8	57.5
	August ..	—	—	64.4	55.8	61.8	52.6	63.7	55.1
	September	—	—	64.5	52.5	60.0	50.0	59.0	50.7

NOTE.—No aftermath cuts were made in 1920, consequently meteorological data are not given for the aftermath period of that year.

and June were, however, much warmer in 1921 than in 1922, but the position was reversed in respect of May. Comparing the hay yields of the first harvest year in each case it will be seen that the 1920 (B.1) crop was decidedly heavier than that of 1921 (B.14), while the crop of 1923, although in its fourth harvest year (B.1), was decidedly heavier than those of 1921 and 1922—respectively in their second and third harvest years—while ordinarily, as Witte has shown, the crop of the fourth harvest year would be expected to be the lightest, in any event as far as the non-indigenous strains are concerned. B.14 again shows the 1923 crop (third harvest year) much heavier than the 1921 crop (first harvest year) and the contrast is greatest in the case of the non-indigenous, and slightly heavier than the 1922 crop (second harvest year). B.60 also shows the crop of 1923 (second harvest year) in the case of both indigenous and non-indigenous to be appreciably heavier than that of 1922 (first harvest year).

Taking the figures as a whole, therefore, it follows that the hay yields for wet 1920 and 1923 have fulfilled the expectations to be drawn from the meteoriological data, and also confirm Witte's conclusions to the effect that when the first and (or) second harvest years are unfavourable for hay production, the yields in the third or fourth year (if the conditions become favourable) are likely to be higher than those of the first or second.

The results given in the Table appear, however, to indicate that indigenous, particularly "tussocks," would probably tend to increase in yield rather than the reverse up to the third or fourth harvest year even if the first harvest year had been as favourable for growth as the third or fourth. The high yields of indigenous agg. in the fourth harvest year (B.1), and of "tussocks" in the second harvest year (B.60), and again in the third harvest year (B.14) are significant in this connection, while indigenous agg. has behaved in a similar manner in broadcast plots.*

The figures for B.1 and B.14 (although presumably favourable to 1921, since this was the first harvest year), indicate that despite the apparent similarity between the meteorological conditions during the hay period of each year, that 1922 was decidedly more favourable to hay production than 1921, and this is particularly striking in the case of the non-indigenous strains ; it is not unlikely that the warmer June of 1921 may here have been an important factor creating a greater physiological dryness during the last (most bulk producing) phase of hay production.

If the meteorological data for the aftermath periods for 1921-22-and 23 (no aftermath cuts were made in 1920) are compared it will be seen that during this period there was no serious lack of rain for either year, indeed, during 1923 the rainfall influencing aftermath production may well have been too excessive to allow of maximum growth, it should also be noted as of possible significance that the aftermath period of 1921 was quite appreciably warmer than either that of 1922 or 1923.

Reference to the aftermath yields show 1921 (see B.14) as a year of outstanding aftermath production. The figures for B.60 show 1922 as giving decidedly higher aftermath yields than 1923, and although the aftermaths were slightly higher in 1923 than 1922 for B.14, the evidence of all the trials under investigation during the two years are in support of the B.60 figures, and indicate clearly that 1921 yielded by far the heaviest aftermaths, and that 1922 gave quite appreciably heavier aftermaths than 1923 (see Table V. p. 25).

* The results from broadcast field trials will be dealt with in a subsequent bulletin.

It appears evident, therefore, that the yield of aftermath is not only influenced by the meteorological conditions obtaining during the aftermath period, but also to some extent at least by the size of the hay crop. Thus, any influences that react against heavy hay production, provided they are not severe enough to cause the plants serious physiological harm—if followed by favourable aftermath conditions, may tend to augment the yield of aftermath as such. The figures for B.14 show 1921 with poor hay yields and very high aftermaths, and 1922 and 1923 both with high or fairly high hay yields and poor or relatively poor aftermaths, while B.60 shows 1923 with higher hay yields than 1922 and decidedly lower aftermath.

The only individual lot which stands out as a striking exception to the above statement is indigenous-tussocks, which in 1923 (B.14) gave its highest hay and its heaviest aftermath, this strain, as previously explained, would seem, however, (see B.60 also) to gain rather than drop in productiveness as the harvest years advance, and it has an outstanding ability for aftermath production.

The apparent inter-relation of yield of aftermath to yield of hay is shown in an even more striking manner by reference to results obtained with Red Clover, which may be more conveniently considered here than in the separate article dealing with that species.

The figures given in Table IV. abstracted from two extensive trials with Red Clover, show the relation of aftermath to hay for the two seasons 1921 and 1923 in respect of trials in their first harvest year in both years.

It is particularly to be noted that the very poor hay yields of 1921 are to be attributed not only to the poor hay conditions of 1921, but in part to the late date at which the plots were " put up " to hay.* All conditions were alike favourable for a heavy hay crop in 1923—well established plants, early " putting up " to hay and advantageous meteorological conditions during the hay period. The yields, despite the obviously superior conditions of 1923, show a surprisingly large difference in favour of the 1923 hay crop. The differences in the aftermath are even greater, but markedly in favour of 1921 (with deplorable hay yields) when all the Broad Reds gave actually higher aftermath than hay yields, and all the lots except Brittany Red showed higher aftermaths in 1921 than in 1923, whilst relative to the hay yields the aftermaths of 1921 were in all cases vastly superior to those of 1923.

The evidence here considered both as to Cocksfoot and Red Clover afford an interesting confirmation of the view tentatively expressed in the earlier bulletin that the after-grass available in 1921 was not only abundant relative to the earlier scarcity, but was actually more abundant than in normal or average years.†

The results given above cannot be taken as sufficient to establish definitely a direct relationship between the yield of aftermath and that of the hay crop more or less independently of the meteorological conditions obtaining during the aftermath period, because complete meteorological data have not been available, information probably being particularly necessary as to soil temperature.

* The relation of date of " putting up " to hay on yield of both hay and aftermath is dealt with in a subsequent section, see p. 38.

† See (32) footnote on p. 92.

Table IV.—*Showing the combined effect of season and date of "putting up" to hay on the yield of hay and aftermath for Red Clover in* 1921 *and* 1923.

The yields, which are given as green weight, include weeds (mainly grasses) as well as Clovers.

Strain or Nationality.	1921. A. 19.						1923. A. 39. V.					
	First cut.			Second cut.		Relative wt. of after-math. hay=100	First cut.			Second cut.		Relative wt. of after-math. hay=100
	No. of lots.	Date of cutting.	lb. per acre.	Date of cutting.	lb. per acre.		No. of lots.	Date of cutting.	lb. per acre.	Date of cutting.	lb. per acre.	
English Late Flowering	4	4/7	8,000	Sept. 21	6,640	82.8	8	24/7	24,170	Oct. 15	3,130	12.9
Montgomeryshire Late..	3	12/7	6,880	,,	7,200	104.7	4	24/7	22,960	,,	2,610	11.4
English Broad Red ..	2	31/6	6,440	,,	10,370	161.0	18	2—6/7	17,350	,,	6,860	39.5
Brittany ,, ,, ..	5	28/6	2,880	,,	5,360	186.1	2	6/7	14,250	,,	7,070	49.6
French ,, ,, ..	1	26/6	3,600	,,	6,320	175.6	4	6/7	15,520	,,	5,710	36.7

A. 19 was sown May 22nd—29th, 1920, and was cut on September 29th of that year, and then grazed by sheep off and on until April 30th, 1921, when it was "put up" for hay.

A. 39, V. was sown on May 29th, 1922, owing to the dry conditions following sowing, there was not sufficient growth by September to cut and weigh the produce. The plots were therefore grazed by sheep from September 21st to October 30th, and then "put up" for hay. Both trials were set out in broadcast 1/100 acre plots on adjoining and similar ground on Penglais field. As is invariably the case with pure Red Clover plots, both trials became weedy (A. 39 V. more so), for the present purpose the yields given by weeds and clover together have been used.

Table V.—*To show relatively the increase in yield over a single hay cut of one and of two aftermath cuts taken in addition to the hay cut.*

Proportionate yields based on green weights in all cases.

Experiment Ref.	and year of cutting.	Species and Nationality	Cut once : hay.	Cut twice : hay and aftermath.	Cut three times : hay and two aftermaths.	Remarks.
B. 14	1921	Cocksfoot Indig. ..	100	178	200	Sown drills 1st harvest year.
		,, Dan. & U.S.A.	,,	149	203	
B. 108	1921	,, agg.	,,	154	212	Single plants.
B. 60	1922	,, Indig.	,,	147	—	Rows of propagants not pre-treated.
		,, Dan. & U.S.A.	,,	140	—	
	1923	,, Indig.	,,	135	—	Rows of propagants which yielded hay and aftermath in previous years.
		,, Dan. & U.S.A.	,,	126	—	
B. 36.	1921	,, Per. Rye, Indig.	,,	158	175	Sown drills 1st harvest year.
		,, Non-indig. ..	,,	140	160	
B. 93.	1922	,, Indig.	,,	120	—	Tiller beds in 1st harvest year.
		,, Non-indig. ..	,,	113	—	
B. 29 I.	1921	Tall Oat, Indig.	,,	159	166	Sown drills 1st harvest year.
		,, French ..	,,	112	121	
	1922	,, Indig.	,,	150	—	Sown drills 2nd harvest year, following hay and aftermath.
		,, French ..	,,	136	—	
	1923	,, Indig.	,,	149	—	Sown drills 3rd harvest year, following hay and aftermath.
		,, French ..	,,	144	—	
B. 21.	1921	Timothy, Indig.	,,	204	232	Sown drills 1st harvest year.
		,, U.S.A.	,,	196	209	
B. 93.	1922	,, Indig. ..	,,	111	—	Tiller beds 1st harvest year.
		,, U.S.A. ..	,,	141	—	
B. 76.	1923	,, Indig. ..	,,	105	—	Rows of propagants following hay and aftermath.
		,, U.S.A. ..	,,	111	—	
B. 56 II.	1923	Cocksfoot, Indig. ..	,,	130	139	Single plants.
		,, Dan. & U.S.A.	,,	132	137	

The relation of yield of aftermath to yield of hay on permanent grass has been investigated by Sutton and Voelcker (28), having particular reference to the date at which the first (= hay) cut was taken.

The more important of these results based on dry weights are given on a percentage basis hereunder :—

Date of Cutting.	(1) Hay.	(2) Hay and one aftermath.	(3) Hay and two aftermaths
(1) June 3rd, (2) Sept. 2nd, (3) Oct. 29th.	100	189	239
(1) June 17th, (2) Sept. 17th.	100	170	—
(1) July 8th, (2) Sept. 29th.	100	143	—

The spring of the year of investigation (1891) was cold and dry, thus on June 3rd the plants were on the average only in the heading stage, the average height of the herbage being 7 in. On June 17th, several, but not all, the grasses were in the flowering state, and the average height of the herbage was 15 in. On July 2nd, several of the grasses had completed flowering, and the average height of the herbage was 20 in.

It is to be noted, firstly, that a very early cut (in this case a pre-hay cut) favoured the development of a relatively large first aftermath and made possible a considerable further contribution in the form of a second aftermath cut ; and, secondly, that the aftermath after a " flowering stage " hay cut was responsible for a greater relative increase in aggregate yield than an aftermath after a " waning flowering stage " hay cut.

The average extra yield from one and two aftermath cuts respectively added to a hay crop for a number of species for the three years 1921-23, is shown relatively (hay yield expressed as 100 in each case) in Table V. The figures are in further confirmation of the exaggerated aftermath yields relative to hay yields of 1921, and show further that a second aftermath cut taken in that year was in all cases competent to add very materially to the gross bulk of hay or hay-like produce. The best comparison in this latter connection is between B. 108 I. for 1921 and B. 56 II. for 1923 (both results on single and very similar plants of Cocksfoot). It will be seen that in 1923 the third cut (= second aftermath cut) was responsible for less than a 10 per cent. increase, while in 1921 the third cut was responsible for an increase to the total bulk of over 50 per cent. (confirmed also by the drill data, *e.g.*, B.14). It will be noted that in years of more normal hay crops (1922, and even 1923 with extra heavy hay yields) in the case of most species an aftermath cut adds very appreciably to the gross bulk, the poorest aftermath grasses being Timothy and commercial Perennial Rye Grass. It is interesting to note that in the case of all species except Timothy relative to the hay yields the indigenous strains have shown a greater aftermathing ability than the non-indigenous.* The poorer ability of indigenous Timothy in this respect is probably due to the extreme lateness with which it comes into flower and therefore into a hay condition. It follows from the evidence here considered that in the case of ordinary herbage species—when the first cut is a hay cut taken at the proper time and subsequent cuts are aftermath cuts, two cuts will yield more than one cut and three more than two. It is, however, evident that in normal years the third cut would not be worth the expense of taking, and would almost always be difficult to harvest, while it is

* The behaviour of indigenous Timothy in 1921 was exceptional, and due to the drought of that year (see (32), p. 14).

at all times open to question whether the after-grass is best taken in terms of a single aftermath hay crop or as grazing (this point is dealt with in a subsequent section) ; the results, however, seem to point to the desirability of taking one aftermath hay crop in years such as 1921, when the hay crop as such has been a partial failure.* Reference to Table II., for instance, shows much less disparity in the yields given by hay and aftermath together between 1921, 1922 and 1923, than in the yields given by the hay crop alone, while the figures quoted from Sutton and Voelcker for dry 1891 show a gain in total prodnce from adding aftermath to hay on a par with that obtained at Aberystwyth in 1921.

B.—The Combined Influence of the Plants Inherent Periodicity and of Meteorological Conditions on Seasonal Productivity under a System of Monthly Pasture Cuts.

Before comparing the gross yields obtained from a system of many with few pasture cuts and with those obtained from the sum of hay and aftermath cuts it will facilitate treatment of the subject to deal with the effect of meteorological conditions on seasonal growth as illustrated primarily by reference to monthly cuts made on Cocksfoot for the three seasons 1921, 1922 and 1923. The yields given by the two trials B.14 and B.60 have been drawn upon. B.14 provides data for 1921 in a first harvest year, B.60 for 1922 in a first harvest year and also for 1923—the cuts made in 1923 were, however, on rows in their second harvest year, but on those which had only yielded hay and aftermath in 1922—so that the three sets of data may be regarded as sufficiently comparable.

The incremental yields as such cannot, however, be usefully compared, but it is the relation of the yields at the different dates to each other that it is desired to contrast. The results for each year are shown in the three graphs, Figure I. for 1921, Figure II. for 1922 and Figure III. for 1923—the yields having been plotted separately for the chief nationalities and strains. The incremental yields given by indigenous and Danish *cum* U.S.A. have also been averaged and plotted as a percentage of total yield for each date—the curves thus obtained for the three years are shown in Figure IV. The rain falling during the days between one cut and the next has been ascertained and is indicated by a rainfall curve in each figure.

If the general form of the curves in Figure IV. is considered it will be noted that each of the three years has conformed to a salient type of curve. We have the slow rise of productivity during March and early April (" awakening period ") followed by a very rapid rise culminating in May or June (" zenith period ") when at the highest point attained in the herbage year (the primary peak) 25 to 30 per cent. of the total produce is developed. This is followed by a rapid fall—a steadying and then a distinct rise giving a secondary peak in the " gradually waning period " and finally by a rapid fall (" rapidly waning period ") until the level of the " dead season " is reached.

* In many districts it is most exceptional to see an aftermath crop of hay under any circumstances, and yet there is little doubt that a judicious resort to this practice in exceptional years would often convert a serious hay shortage into an adequate sufficiency. Under grazing conditions in 1921, for instance, there was a great waste of aftergrass accompanied by a serious shortage of hay. In regions of high rainfall the possibility of converting surplus aftergrass into silage should be considered.

FIGURE I.—*To show the yield from each of seven monthly cuts (green fodder) during 1921 for two salient types of Cocksfoot. The rainfall in inches during the cutting periods is also shown.*

Yield in ozs. per 52in. drill. B.1. 1921.

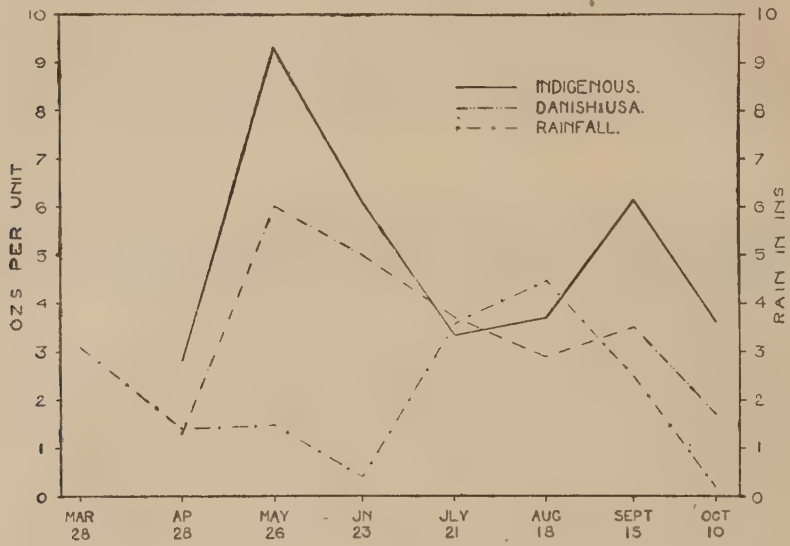


FIGURE II.—*To show the yield from each of ten monthly cuts (green fodder) during 1922 for four nationalities and strains of Cocksfoot. The rainfall in inches during the cutting periods is also shown.*

Yield in ozs. per 20ft. row. B. 60. 1922.

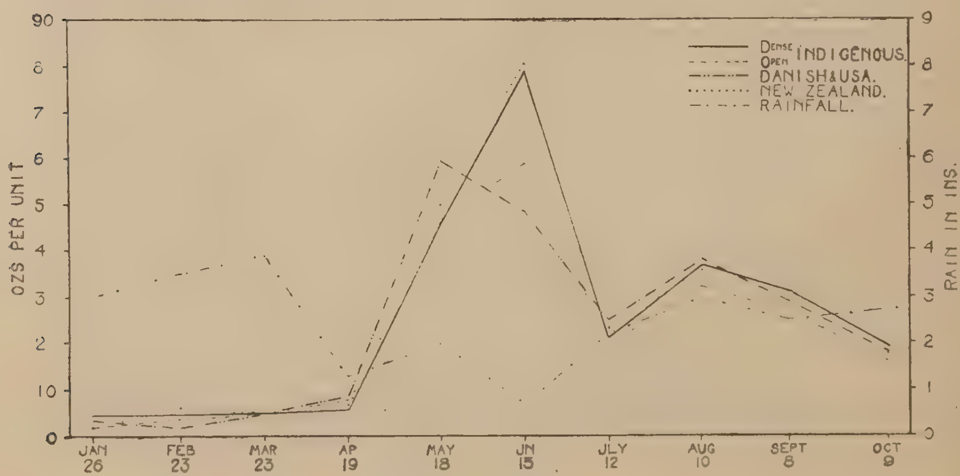


FIGURE III.—*To show the yield from each of seven monthly cuts (green fodder) during 1923 for four strains and nationalities of Cocksfoot. The yields on March 10th representing growth from November are also shown, as is the rainfall in inches during the cutting periods.*

Yield in grams. per 10ft. row. B. 60. 1923.

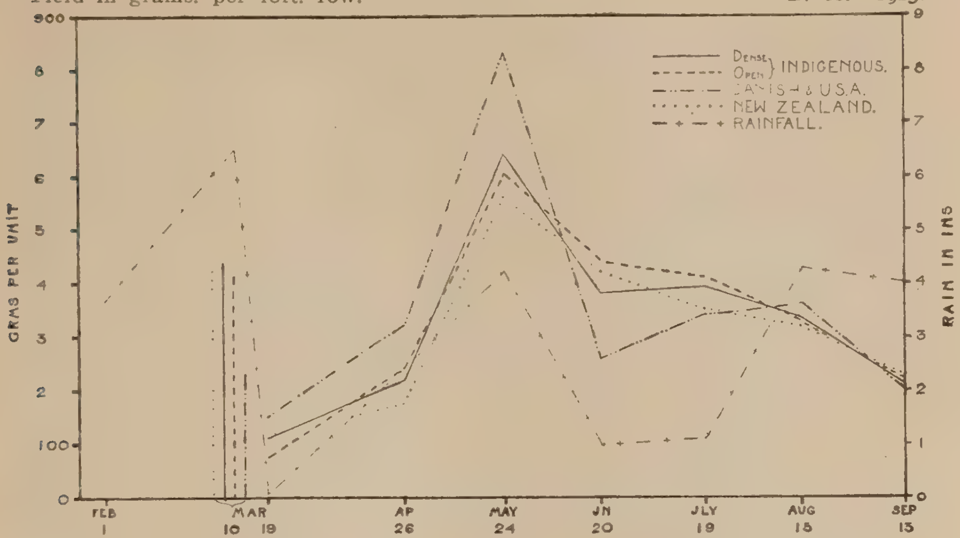
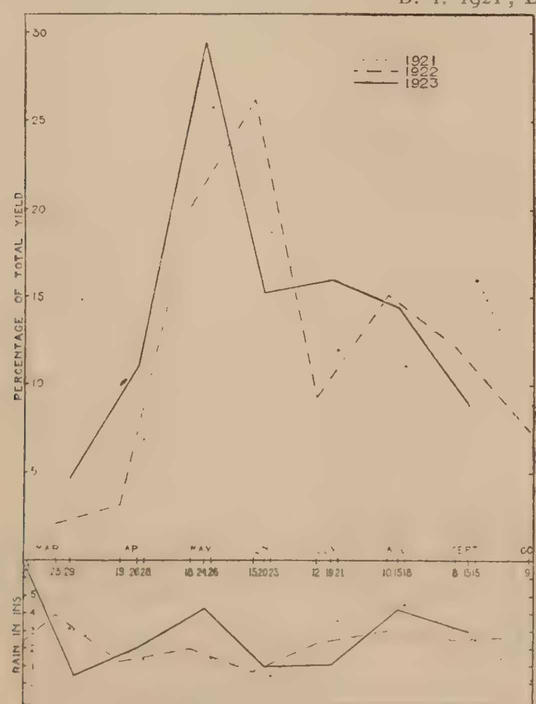


FIGURE IV.—*To show relatively the yield from each of the seven or eight monthly cuts for the three years* 1921, 1922 *and* 1923 *respectively in the case of the average of Indigenous and Danish cum U.S.A., Cocksfoot. The rainfall in inches during the cutting periods is also shown for the three years separately.*

Yields expressed as percentages of total yield based on green fodder.

B. 1. 1921; B. 60, 1922 and 1923.

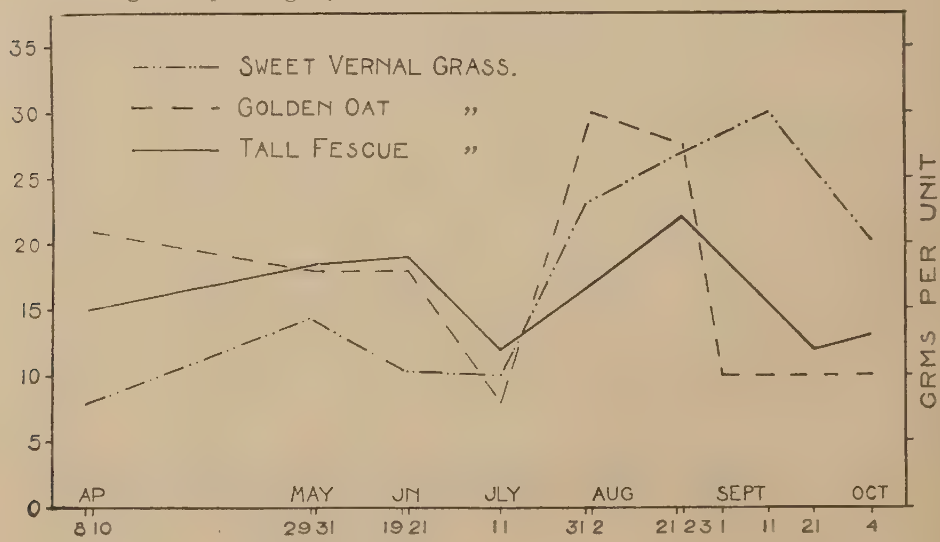


It is interesting to note that the maximum growth under a system of relatively lenient pasture cuts coincides with the period associated with maximum hay development and that this flush of growth is followed by a rapid fall and then by a rise which coincides more or less well with the period of aftermath production. The evidence of the curves in conjunction with the rainfall data strongly suggests that the incremental growth is not only influenced by the climatic conditions but is also a function of a pronounced periodic tendency on the part of the plants. This cannot be absolutely proved by the data available for in each year there was a sharp drop in the rainfall at or soon after the culminating point in May or June. In 1923, however, the rain falling during May and early June should have been sufficient to maintain growth at a fairly uniform level during the remainder of that month and early July—but the rapid fall in productivity was none the less apparent, and was followed by a quite definite though slight rise, giving an appreciable secondary peak. In relation to May and June it is particularly to be noted that in 1921 and 1922 despite very low rainfall at this period the primary peak was strikingly developed.

The relation of the primary to the secondary peak is undoubtedly variable and much influenced by conditions, thus with single plants cut during 1922 it was noted in the case of Sweet Vernal Grass, Golden Oat Grass and Tall Fescue, that the secondary peak actually rose higher than the primary, the curves for the three species are shown in Figure V. Reference to Figure I. on page 140 in the article on Red Clover shows a somewhat different curve to that given by the majority of the grasses. In the case of the clover maximum productivity was not attained to until July 26th, and was followed by a sharp drop with a tendency to steady during September, but no further peak was developed before the cuts were discontinued at the end of that month.

FIGURE V.—*To show the yield from each of eight three weekly cuts (green fodder) for Sweet Vernal Grass agg. (B. 69), Golden Oat Grass agg. (B. 23) and Tall Fescue agg. (B. 72).*

Yield in grams. per single plant. 1922.



Cuts taken in 1923 on a permanent sward (E.30 III.) showed a curve somewhat similar to the clovers with a late primary peak (July 18th), and then a steady drop to October 29th, with no tendency in the direction of a secondary peak.

The periodic aspect of the incremental growth curves would seem to be intimately connected with the flowering propensities of the plants. The Red Clovers (even the early Reds) flower decidedly later than the grasses here considered, while under a system of monthly cuts the flowering date is considerably postponed, and it is shown in a subsequent article that the primary peak coincided with the maximum production of flowering heads—in this case as late as July 26th and during August, the season being too far advanced to allow of the development of a secondary peak. The permanent sward consisted largely of Bent and Wild White Clover, both late flowering plants, and again we have a late primary peak—too late to allow of a secondary peak.

With Cocksfoot and other grasses inflorescences tend to be produced as with Red Clover, even in the short periods (one month) available for their development, but as well as the grasses normally flowering earlier than Red Clover, cutting does not exercise the same delaying effect on maximum production of inflorescences, and thus we find the primary peak coinciding closely with the period associated with hay harvest.

Inflorescence counts have not been made on drills with the grasses, but only on single plants cut on a monthly schedule. Average figures obtained from counts on over 100 plants of Cocksfoot in 1922 show that the greatest number of small inflorescences were developed in cuts taken at the end of May and up to June 20th, the average number being 19 per plant per cut ; cuts taken after this maximum show for the next two cuts, namely, in July and early August, an average of only 1.75 per plant per cut ; by the middle of August the number had again risen, and had reached 5 per cut ; early in September the average was only one, and in October none.

When individual plants are compared it is found that the maximum yield is not necessarily given by the particular plant or by the particular cut showing the most inflorescences—that is to say, it is not the inflorescences as such that have materially contributed to the yield. The point of interest is the fact that both the primary and secondary peaks are associated *in time* with the periods during which, even under comparatively severe cutting, inflorescences *tend* to be the most freely developed, and they are more freely developed during the period of the primary than of the secondary peak.

In the case of Golden Oat Grass, which gave a higher secondary than primary peak, it is to be noted that the cut on June 21st was associated with eleven inflorescences, that on July 12th with two, and those on August 2nd and September 23rd with an average of 9.5. In the case of Sweet Vernal Grass and Tall Fescue there were, however, very few inflorescences developed subsequent to the cuts associated with the primary peak—these curves are, however, again referred to when dealing with stem and leaf ratios.

Further reference to Figure IV. shows interesting differences in the quality of the curves for the three years. As already noted, even in 1921 and 1922 growth attained to a maximum in May-June, that is to say, the highest yields synchronized with the lowest rainfall in both years. The effect of the drought showed itself qualitatively immediately afterwards, for in both years the post zenith drop was relatively greater than in 1923, and in both years the drop was

continued for some time against a substantial late June and early July rainfall (a higher rainfall than that experienced in 1923 at this period).

Although more rain fell during July, August and September in 1921 than in 1922, the secondary peak was developed earlier in the latter year, when it coincided with the maximum rainfall, in 1921 the secondary peak lagged appreciably behind the maximum rainfall (thus again suggesting the greater physiological dryness of the earlier part of 1921), but although delayed until the middle of September it was particularly pronounced, giving as high a proportion of total yield as that of 1923, but nearly three months later.

The chief features in connection with 1923 were the earlier start into active growth, earlier and greater proportionate yields at the zenith peak—all under the influence of higher early rainfall—and despite a rather low rainfall middle June to middle July—a more rapid steadying and almost immediate development of a secondary peak which showed itself before the advent of renewed heavy rain. It is thus apparent that both quantitatively and qualitatively the pasture growth curve is not of necessity immediately responsive to the meteorological conditions obtaining in a particular incremental stage—but is undoubtedly affected to a more considerable extent by the amount of rain falling in earlier incremental periods, and presumably also by the functional periodicity of the contributing plants.

The comparative behaviour of the different nationalities and strains in the three years (see Figures I, II. and III.) calls for brief mention. It will be noted that in 1921 indigenous Cocksfoot was superior to Danish *cum* U.S.A. at practically all incremental stages even early in April. In 1922 Danish *cum* U.S.A., and French showed their more normal earlier growth and were superior to indigenous up to May 18th; the indigenous were, however, vastly more productive than their commercial counterparts during the latter part of May and throughout most of June. During July, August and September, the best indigenous and the best commercial (Danish *cum* U.S.A.) were about on a par. In 1923 Danish *cum* U.S.A. were seen to the best advantage, from March 29th until the middle of June, when they outyielded indigenous by a fairly substantial margin. From June 20th till nearly the middle of August the advantage was emphatically with the indigenous, thereafter the yields from all the nationalities were very similar. Reference to Figures II. and III. shows a remarkable similarity between the behaviour of indigenous dense-pasture and New Zealand, the same figures also indicate the relative superiority of indigenous over Danish *cum* U.S.A., during the dead season, as illustrated by cuts taken on and before March 23rd.

These results are in keeping with those discussed in the earlier bulletin, and confirm the relative superiority of indigenous strains under conditions of drought.

C.—The gross yields from the sum of Hay and Aftermath Cuts compared with those given by various systems of Pasture Cuts. A large amount of data is available for making comparisons between the gross yields obtained from various systems of cutting both from single plants and from rows and drills over the three year period 1921—23. It is not necessary to burden the paper with detailed yield tables since the differences under consideration will be found to be of a magnitude which render critical examination of a vast mass of figures superfluous, the results are therefore given on a percentage basis

with the sum of the hay and one or more aftermath cuts expressed as 100 and the yields from the various systems of pasture cuts given as a percentage of the hay or hay *cum* aftermath yields. The results from drills and rows are given in Table VI., and those from single plants in Table VII. In practically all cases the figures are based on first harvest year data, when second harvest year results have of necessity been used only drills, or rows previously yielding hay and aftermath have been employed, thus the disturbing influences of pre-treatment can safely be taken as having been eliminated in all cases, while only healthy and initially well established drills and plants completely free from weeds have been brought under review.

When comparing hay cuts or hay *cum* aftermath cuts with pasture cuts, or when comparing few pasture cuts with many pasture cuts, the results will be very different, although in the same direction, according as dry weights, hay weights, or green weights are considered. This is well shown by the following figures given by Lindhard (15) for Cocksfoot :—

	Cut twice.	*Cut 3 times.*	*Cut 4 times.*	*Cut 6 times.*
As green fodder	100	113	89	75
As hay	100	79	55	45

When hay or aftermath or only a very few pasture cuts are taken the gross produce will contain a higher percentage of dry matter than will that from a considerable number of pasture cuts—thus on a green weight basis the pasture bulks are favoured relative to the hay. The relation of dry matter to total weight is dealt with in a subsequent section. Since most of the results given in the tables are based on green weights it is, however, necessary to emphasise the fact that the comparisons between few and many cuts would have been even more striking had they all been presented in terms of dry weights.

Examination of the tables shows marked general agreement between the behaviour of drills and of single plants and it will be noted that in all cases a system of hay and aftermath or hay and after cuts has shown a higher yield than all systems of pasture cuts—even when as few as four pasture cuts have been taken, remembering that pasture cuts are only regarded as such when the first cut has been taken before the flowering stage.

In proportion as the number of pasture cuts is increased so is the aggregate yield decreased. This is well shown by the Cocksfoot data obtained in 1921 (B.14 drills and B.108 I. single plants), and is borne out by a general review of the figures.

Drastic systems of cutting have a greater depressing effect on yield in dry than in more normal years—thus Cocksfoot cut ten and eight times in 1922 and 1923 gave higher gross yields than when cut but seven times in 1921 (see Table VI., comparable green weight data).

The relative behaviour of the species shows interesting features, thus in 1921 under a drastic system of cutting, Cocksfoot and Tall Oat Grass showed to poorer advantage in comparison with their hay yields than Perennial Rye Grass, Timothy or Crested Dog's Tail. The figures for 1922 and 1923 show Tall Fescue particularly sensitive to even lenient systems of pasture cutting, while Sweet Vernal Grass compares very favourably with the Rye Grasses. Taking the figures as a whole, and despite the fact that Sweet Vernal Grass and Crested Dog's Tail showed to relatively good advantage under a system of pasture cuts compared to hay *cum* aftermath, it would not seem justifiable

TABLE VI.—*To compare the yields from the sum of a hay and aftermath cut with those given by various systems of pasture cuts.*

The former yields expressed as 100 in each case and the latter as a percentage. Based on green weights from drills or rows.

Expt. ref.	Year.	Species.	Cut twice: hay and aftermath.	Number of pasture cuts. Six or seven*	Eight or ten*	Thirteen.	Range of dates for pastive cuts.
B. 14.	1921	Cocksfoot agg.	100	56 (7)	—	39	Cuts starting 13/4 and ending 18/10
		Perennial Rye Grass ,,	100	—	—	55	,, 13/4 ,, 18/10
		Timothy ,,	100	—	—	58	,, 13/4 ,, 18/10
		Tall Oat Grass ,,	100	—	—	36	,, 13/4 ,, 18/10
		Crested Dog's Tail ,,	100	—	—	78	,, 13/4 ,, 18/10
B. 14.	1922	Cocksfoot ,,	100	—	69 (10)	—	,, 25/4 ,, 10/10
B. 60.	1922	Cocksfoot ,,	100	—	78 (10)	—	,, 26/1 ,, 9/10
B. 29.	1923	Tall Oat Grass ,,	100	58 (6)	—	—	,, 8/5 ,, 6/10
B. 60.	1923	Cocksfoot ,,	100	—	64 (8)	—	,, 1/4 ,, 13/9
B. 75.	1922 & 1923	Per. Rye Grass ,,	100	—	67	—	1922 (10 times) 26/1—9/10; 1923 (8 times) 1/4—13/9
B. 76.	averaged	Timothy ,,	100	—	76	—	
B. 77.		Tall Oat Grass ,,	100	—	77	—	

* The figures in brackets showing the precise number.

TABLE VII.—*To compare the yields from the sum of hay and aftermath cuts with those given by various systems of pasture cuts.*

The former yields expressed as 100 and the latter as a percentage. Based on data from single plants.

Expt. ref.	Year.	Species.	When first cut=hay.			Number of pasture cuts.						Range of dates for pasture cuts and method of weighing.
			Cut twice : hay and aftermath.	Cut 3 times : hay and 2 aftermaths.	Cut 3 times : hay and 2 aftercuts.	Four.	Five.	Six.	Seven.	Eight or ten.	Seventeen.	
B.108 I.	1921	Cocksfoot agg. ..	—	100	—	—	—	—	40	21 (10)†	16	Dry wts. 18/4—27/10 in all cases.
B.59	1922	Sweet Vernal Grass, agg. ..	100	—	—	—	—	—	—	59 (8)	—	Green wts. 8/5—4/10
B.70 I.	1922	Tall Fescue agg. ..	100	—	—	—	—	—	—	30 (8)	—	Green wts. 9/5—4/10
B.91	1922	Per. Rye Grass agg.	—	—	100	—	—	—	—	64 (8)	—	Green wts. 25/4—21/9
B.92	1922	Ital. Rye Grass agg.	—	—	100	86	—	—	—	—	—	Green wts. 6/5—29/9
B.56 II.	1923	Cocksfoot agg. ..	—	100	—	—	—	—	62	—	—	Green wts. 6/5—29/9
B.108III	1923	Cocksfoot Ind. ..	—	100	—	—	—	—	42	—	—	Dry wts. 13/3—20/9
B.59	1923	Sweet Vernal Grass agg.	100	—	—	89	—	—	—	—	—	Dry wts. 27/3—14/8
B.70 I.	1923	Tall Fescue agg. ..	100	—	—	38	—	—	—	—	—	Dry wts. 22/3—14/8
B.111	1923	Per. Rye Grass agg.	—	—	100*	—	—	77	—	—	—	Green wts. 23/4—4/10
B.113	1923	Timothy agg. ..	—	—	100	—	60	—	—	—	—	Green wts. 7/5—17/9
B.95	1923	Red Fescue agg. ..	100	—	—	—	58	—	—	—	—	Green wts. 27/4—5/9

* Some of the lots cut four times, *i.e.*, hay plus 3 after cuts.
† Figures in brackets showing the precise number.

to assume that grasses which are regarded more essentially as pasture plants necessarily give the highest pasture to hay *cum* aftermath ratios, the behaviour of Red Fescue being for instance incompatible with such an assumption. It has been previously reported that " dense pasture " plants showed to better advantage under a hay *cum* aftermath than under a pasture system of cutting. The figures given hereunder comparing non-indigenous with indigenous strains of Cocksfoot are interesting in this connection, having regard to the fact that the indigenous may be regarded rather as " pasture " and the non-indigenous as " hay " strains :—

B.108 *I., Single plants*, 1921.		
Cut twice.	100 indigenous.	91 Danish *cum* U.S.A.
Cut 7 times.	100 ,,	96 ,, ,, ,,
Cut 17 times.	100 ,,	87 ,, ,, ,,
B.60. *Drills*, 1922.		
Cut twice.	100 ,,	70 ,, ,, ,,
Cut 10 times.	100 ,,	97 ,, ,, ,,
B.60. *Drills*, 1923.		
Cut twice.	100 ,,	71 ,, ,, ,,
Cut 8 times.	100 ,,	98 ,, ,, ,,

In the case of Timothy the following comparison can be made :—

B.76. *Drills*, 1923.		
Cut twice.	100 indigenous.	70 U.S.A.
Cut 8 times.	100 ,,	76 ,,

The conclusions to be drawn from the above statement would appear to be as follows :—A plant's productivity under a system of repeated cuttings is a function of two distinct abilities :— the ability to remain healthy and vigorous despite the treatment, and a capacity to start growing immediately after each cutting and to grow rapidly during each incremental period. The highest yielding plants will presumably therefore be those endowed with both inherent persistency and with a capacity for " picking up " quickly. In a favourable season and in the case of plants not stunted by previous adverse conditions or treatments, the capacity for " picking up " quickly has a very pronounced influence on yield, and may be sufficient to counterbalance rather poor persistency. In an unfavourable season or when the plants have been deprived of their full vigour by previous treatments or adverse conditions, persistency will have the dominating influence. Similarly a too drastic system of cutting in a particular season will tend to favour the more persistent rather than the more quickly " picking up " plants. Thus in 1921 commercial Cocksfoot has stood at a better ratio to indigenous when cut seven times than when cut twice, but at a considerably lower ratio when cut 17 times.* The comparison made between Broad Red Clover and Late Flowering Red in a subsequent article (see Figure V., p. 148) bears out this view, Broad Red standing at a better ratio to Late Flowering Red under a system of pasture cuts than on a hay comparison. In a broad way, it is probably true to say that those herbage plants that " pick up " most quickly are not as a rule as persistent as those that " pick up " less quickly. This is an important point that will be considered in greater detail when discussing pre-treatments.

* The present investigations bear out the earlier work, and show that, speaking generally, typical indigenous strains of grasses are slower growing and more persistent than the typical non-indigenous, just as Late Flowering Red Clover is slower growing and more persistent than the Broad Red, or Wild White Clover, than Ordinary White Dutch.

Table VIII.—*Data obtained in* 1922 *on drills and in* 1923 *on sward plots to show relatively the effect on yield of hay and aftermath, of " putting up " plot units for hay at different dates.*

Results based on yield given in green weights.

Ref. to expt.	Particulars of trial.	Plots " put up " in February or March. Loss or gain per cent. compared with plots " put up " in December.				Plots " put up " in April. Loss or gain per cent. compared with plots " put up " in December.			
		On hay crop only.	On hay when cut representing Dec. to Feb. is added.	On hay and aftermath together.	On hay and aftermath when cut representing period Dec. to Feb. is added.	On hay crop only.	On hay when cut representing Dec. to April is added.	On hay and aftermath together.	On hay and aftermath when cut representing period Dec. to April is added.
				1922	DATA.				
B. 60	Cocksfoot. Each result based on the average of 60 twenty ft. drills ..	— 2	+ 1	— 4	— 2	— 20	— 10	— 17	— 10
B.75 and B.76	Perennial Rye Grass and Timothy. Each result based on average of 30 twenty ft. drills ..	— 3	— 2	— 1	equal.	— 24	— 5	— 8	— 4
				1923	DATA.				
E.30 I.	Temporary Ley in first harvest year. Mixture Per 10.5; Cocks. 8.1; Tim. 4.7 ; Mont. Red, 4.2 lb. per ac. Plots 1/400 ac. not replicated	— 3	equal.	— 4	— 2	— 21	— 4	— 20	— 7
E.30 III.	Permanent Meadow : Plots 1/100 acre X. 4	— 5	— 1	— 4	equal.	— 16	— 7	— 12	— 5

B.60, B.75, and B.76.—The " December," " February," and "April " drills were alike in all cases cut on December 1st. The " December " drills were then allowed to grow on till hay. The February drills were cut on February 28th, and the herbage produced December 1st to February 28th weighed, the drills then being allowed to grow on to hay. In all cases the April drills were cut on April 19th, and the herbage produced December 1st to April 19th weighed—the drills then being allowed to grow on till hay. The hay was cut for each lot when in full flower ; some of the April "put up " lots were not ready for cutting until nearly a month later than the December put up equivalents. E.30 I.—The plots were grazed by sheep until December 30th, 1922. The " December put up " was not again cut until hay harvest. The February " put up " plot was cut with a lawn mower on February 28th and the produce representing growth December 30th to February 28th weighed. The April " put up " plot was cut with a lawn mower on April 27th and the produce representing December 30th to April 28th weighed. E.30 III.—The field had been used as a meadow since 1917—and previously had been used for some years as a pasture, but had also yielded a hay crop in 1912.

The whole field had been grazed by sheep in December, 1922, and on December 26th the plot area was cut with a hay reaper in order to remove fog. The " put up " December plots were allowed to run on to hay from this latter date. In this case one series of plots was put up in March instead of February, these plots being cut with a lawn mower on March 31st, the April series were similarly cut with a garden mower on April 26th.

D.—The effect of the Date at which a system of Cutting is started on the Aggregate Yield obtained during a current season.

(1) HAY *cum* AFTERMATH: INFLUENCE OF DATE OF "PUTTING UP" FOR HAY ON YIELD. It has been previously shown that in dry 1921 drills of Cocksfoot "put up" for hay in November, 1920—that is to say cut for the last time before hay harvest in November—yielded over twice as much hay as drills "put up" (cut for the last time) in April, 1921.*

Trials of a similar nature were again conducted during 1922 and 1923. The results have been summarised and are set out on a percentage basis in Table VIII. It should be noted that drill and sward data are in marked general agreement. It will be apparent that the results have not been so striking as in 1921, and that in the more normal years 1922 and 1923 "putting up" in February as opposed to December, has not occasioned a very appreciable reduction in hay or aftermath, and that when these reductions are counter-balanced by the herbage produced between December and February the loss in gross yield has been negligible. It is significant, however, that even in a wet year like 1923, plots "put up" in April compared with those put up in December have shown substantially reduced hay and hay *cum* aftermath yields. The later "putting up" having influenced the yield of aftermath, although to a lesser degree as well as of the hay—the reductions for hay *cum* aftermath on sward plots having amounted to 12—20 *per cent.* Appreciable reductions (4—7 *per cent.*) are also apparent when the diminished hay *cum* aftermath yields have been counter-balanced by the herbage produced from December to April.

In grassland districts in Wales and in the West of England it is no uncommon practice for meadows to be grazed by sheep even into May, a procedure which probably has a greater depressing effect on hay yield than is generally appreciated, and also of course tends to make hay harvests late.

The results here given add emphasis to the importance of supplementing March and April keep by every possible means.

(2) PASTURE CUTS: INFLUENCE OF THE DATE OF THE FIRST CUT ON THE AGGREGATE YIELD FROM A SYSTEM OF CUTS. A number of trials have been conducted bearing on this point, and since the matter appears to be of considerable practical importance the results are given in detail in Tables IX., X. and XI., and in Figure VI.

In the tables the actual weights of produce are shown in bold figures. The figures in square brackets give comparisons vertically, that is to say, between indigenous (at 100) and the other nationalities for each system of cutting as such. The figures in round brackets constitute horizontal comparisons, that is to say, between one system of cutting with another (the system giving the maximum gross yield is placed at 100) for each nationality separately and as such.

It will be noted that the data presented in each of the three tables are in marked agreement. The essential facts are brought out by reference to columns (2), (3) and (4) of Tables IX. and X. On the basis of the average figures of indigenous *cum* Danish *cum* U.S.A., it will be seen from Table IX. that when the first cut was postponed until May 5th, the aggregate yield from eight cuts (May 5th to September 9th) has been 40 *per cent.* in excess of that given by eight cuts taken over the same period when three cuts (starting March 1st) had

* See (32), Table VIII., p. 26.

TABLE IX.—*To compare the gross yield from drills of Cocksfoot cut eight times from May 5th to September 9th, when the cut on May 5th was the first cut for the season, with the gross yield from eight cuts taken over the same date range (May 5th—September 9th) when three pre-cuts were made respectively on March 1st, March 22nd and April 4th. The figures in square brackets are vertical comparisons, those in round brackets horizontal comparisons (see text). The weight of produce from the three pre-cuts (March 1st—April 4th) and from the sum of eleven cuts (March 1st—September 9th) are also shown.*

Green weights in ozs. per 52-in. drill, third harvest year data. B. 14, 1923.

(1)	(2)	(3)	(4)	(5)
Nationality and number of lots.	Sum of three cuts March 1st—March 22nd, April 4th.	Sum of eight cuts May 5th—September 9th, when May 5th the first cut of the season.	Sum of eight cuts May 5th—September 9th, when three pre-cuts previously taken : see col. (2).	Sum of eleven cuts March 1st— September 9th.
Indigenous .. .. (8)	7.4 [100] (22)	32.7 [100] (100)	22.3 [100] (68)	29.7 [100] (91)
Danish *cum* U.S.A. .. .. .. (7)	4.5 [60] (15)	29.1 [89] (100)	15.1 [67] (51)	19.6 [66] (67)
French .. .. (2)	2.9 [39] (15)	18.8 [57] (100)	10.2 [45] (54)	13.1 [44] (69)
Average of Indigenous and Danish *cum* U.S.A.	5.9 [—] (19)	30.9 [—] (100)	18.7 [—] (60)	24.6 [—] (79)

TABLE X.—*To compare the gross yield from single plants of Cocksfoot cut six times from May 10th to October 7th, when the cut on May 10th was the first for the season, with the gross yield from six cuts taken over the same date range (May 10th—October 7th), when a pre-cut was made on April 11th. The figures in square brackets are vertical comparisons, those in round brackets horizontal comparisons (see text). The weight of produce from a single cut, April 11th, and from the sum of seven cuts, April 11th—October 7th, and the average heading dates are also shown. Propagants of the same plants were used for each system of cutting.*

Green weights in grammes per unit of three propagants. First harvest year data. B. 56 II. 1923.

(1)	(2)	(3)	(4)	(5)	(6)
Nationality and number of plants.	Single cut. April 11th.	Sum of six cuts May 10th—Oct. 7th, when May 10th the first cut of the season.	Sum of six cuts May 10th—Oct. 7th, when pre-cut on April 11th.	Sum of seven cuts April 11th—Oct. 7th.	Heading date.
Indigenous .. .. .. (11)	83 [100] (21)	386 [100] (100)	245 [100] (63)	328 [100] (85)	27th May.
Danish *cum* U.S.A. .. .. (6)	104 [125] (21)	487 [126] (100)	243 [99] (50)	347 [106] (71)	13th May.
French .. .. .. (2)	114 [137] (23)	488 [126] (100)	195 [75] (40)	309 [94] (63)	4th May.
Average of Indigenous and Danish *cum* U.S.A.	94 [—] (21)	436 [—] (100)	244 [—] (58)	337 [—] (77)	—

TABLE XI.—*To compare the gross yield from single plants of Tall Fescue cut six times from May 7th to October 7th, when the cut on May 7th was the first cut for the season, with the gross yield from six cuts taken over the same date range (May 7th to October 7th) when a pre-cut was taken on April 11th. The figures in round brackets are horizontal comparisons (see text). The weight of produce from the pre-cut on April 11th is also shown.*

Green weights in grammes per unit of three propagants, three plants being under test. First harvest year data. B. 72 II. 1923.

Single cut April 11th.	Sum of six cuts May 7th to October 7th, when May 7th was the 1st cut of the season.	Sum of six cuts May 7th to October 7th, when pre-cut on April 11th.
115	407	259
(28)	(100)	(63)

been previously taken, and this despite the fact that the produce of the three cuts (March 1st—April 14th) only amounted to 19 *per cent.* of the eight cuts May 5th to September 9th, starting on May 5th. Thus the gross yield from eleven cuts March 1st—September 9th has been 21 *per cent.* less than the gross yield from eight cuts, May 5th to September 9th. The results given in Table X. are remarkably similar to those in Table IX.—the figures in the former table show the produce from seven cuts, April 11th to October 7th, as being 23 *per cent.* less than that from but six cuts, May 10th to October 7th. These figures are the more striking since a single *pre-cut* of no more than 21 *per cent.* of the aggregate of the six cuts (May 10th—October 7th) had alone been responsible for this remarkable difference in yield. The figures in Table X. are, moreover, exceptionally reliable since each system of cutting was conducted on propagants of the same group of plants. It will be seen from Table XI. that Tall Fescue has behaved in a manner precisely similar to Cocksfoot.

A comparison of the behaviour of indigenous Cocksfoot with Danish *cum* U.S.A. gives the clue to the wide differences in yield. It will be noted that indigenous has stood in the best relation to non-indigenous (c.f. figures in square brackets, vertical comparisons) when *pre-cuts* have been taken—but that non-indigenous have shown to the best relative advantage when the first cut of the season was deferred until May. The figures from the two tables are as follows :—

	ex. Table IX.		*ex. Table* X.		*Heading*
	Pre-cut.	*Not pre-cut.*	*Pre-cut.*	*Not pre-cut.*	*date.*
Indigenous	100	100	100	100	27/5
Danish *cum* U.S.A. ..	67	89	99	126	13/5

It is to be observed that the Danish *cum* U.S.A. "headed" 14 days earlier than the indigenous, thus when the first cut was not taken until early in May the Danish *cum* U.S.A. had nearly fully headed while the indigenous were far from heading. While in the case of cuts taken earlier (*i.e.*, the pre-cuts) neither nationality would have approximated to the heading stage. It thus appears evident that when the first cut is taken before heading, or before heading has well started, the gross yield obtainable from a system commencing at such an earlier date will be less than when a start is made at or but little before the heading stage—this is on all fours with the fact previously recorded that a system of cutting started at flowering stage will out-yield a system started previous to it.

If the yields of different strains as well as nationalities are considered, and comparing the aggregate produce from six cuts starting on May 10th *without a pre-cut*, with the six cuts starting at the same date *after a pre-cut* (B.56 II.) in relation to heading date, we have the following figures :—

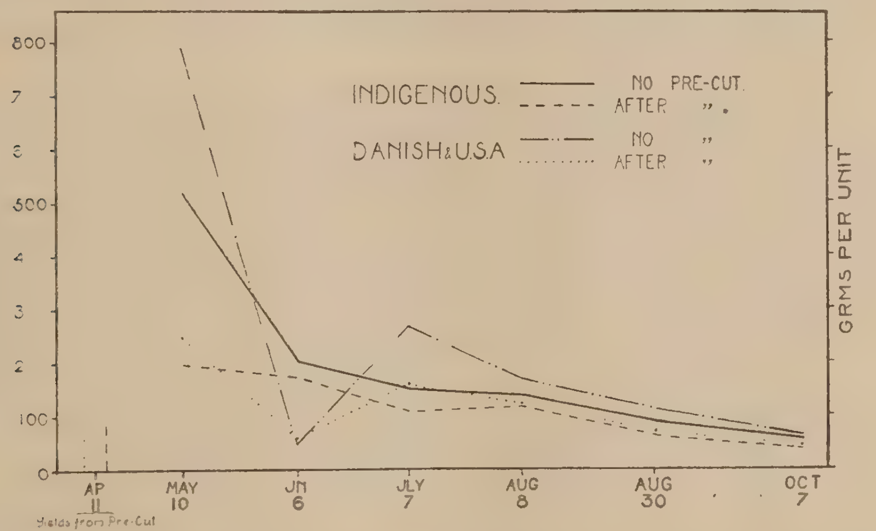
	Average heading date.	*Six cuts May 10th to October 7th (May 10th 1st cut).*	*Six cuts May 10th to October 7th (Pre-cut on April 11th).*
Indigenous dense pasture ..	31/5	100	69
Indigenous tussocks	27/5	100	62
Danish *cum* U.S.A.	13/5	100	50
French	4/5	100	40

It will be seen from the above comparison that indigenous dense pasture with the latest heading date has maintained the highest ratio, *after a pre-cut* : *without a pre-cut*, and that French with the earliest heading date, has maintained

the lowest relative yield, and that the four strains and nationalities give a perfect sequence in relation to heading date. French, therefore, which had come into full head by early May was relative to its inherent yielding capacity more favoured than any other strain or nationality by a system of cutting not started until the first or second week of that month. The above results and conclusions are in keeping with those previously recorded by Lindhard (15), who found that the greatest yields were obtained from systems of cutting which were not initiated until the inflorescences had emerged.

FIGURE VI.—*To compare the yields of Indigenous with Danish cum U.S.A., Cocksfoot from each of six monthly cuts,* (a) *when the cut on May 10th was the first cut of the season, and* (b) *when a pre-cut had been made on April 11th. The yields from the pre-cut on April 11th are also shown for each nationality.*

Yields in grams. (green fodder) per unit of three propagants. B. 56 II. 1923.



The yields from each cutting date, May 5th to October 7th for B.56 II., have been plotted and are shown in Figure VI. both for indigenous and Danish *cum* U.S.A. It will be noted that the most striking differences in yield between the *pre-cut* and *not pre-cut* plants was on May 10th and that this difference was most marked in the case of Danish *cum* U.S.A. (early heading).

It is significant, however, that at all dates (with the almost negligible exception of Danish *cum* U.S.A., on June 6th), the *non pre-cut* have outyielded the *pre-cut*. and again this is most striking in the case of Danish *cum* U.S.A. The results from B.14 were similar in this respect.

The evidence here brought forward, together with that previously discussed relative to date of "putting up" to hay, would seem to suggest, at all events in the case of the larger, and generally speaking, earlier grasses, that heavy grazing early in the spring can only be compatible with reduced yields subsequently, and further, having regard to the fact that "putting up" to hay in February did not show much gain over "putting up" in December,

it would appear likely that heavy grazing would have the most depressing influence on plants which have commenced active growth, but have not attained to their heading stage. Apart from the evil influences of "poaching" wet or heavy ground, it is not unlikely therefore that excessive grazing, say from November to the end of February, has a less deleterious effect on grasslands than excessive grazing during March and April.

In this connection it is significant to note that Tall Oat Grass, Tall Fescue, and to a lesser extent, Cocksfoot, all grasses which commence growth early in the spring, the two former particularly so, are species which if grazed very heavily during March and April do not persist long in temporary leys. This question is dealt with further when considering pre-treatments, it must be explained, however, that the deductions to be drawn from these and other data presented in this report do not necessarily apply, at all events without considerable reservations, to permanent or more or less permanent swards. For in such cases almost infinite inter-specific re-adjustments are to be expected in the floristic composition of the herbage in sympathy with even the slightest modification of management.

(3) YIELDS FROM AFTER-CUTS COMPARED WITH PASTURE CUTS TAKEN OVER THE SAME RANGE OF DATES. Earlier investigations with Cocksfoot at Aberystwyth have shown that in 1921 "after-cuts" taken from the end of June to the middle of October out-yielded the pasture cuts, representing the same range of dates and taken on the same dates from a system initiated in March.* These results again showing that systems started before panicle emergence are less productive of gross yield than those started subsequently. Further evidence of a markedly confirmatory nature has been obtained during the two more normal years 1922 and 1923. Typical results are set out in Table XII. for Timothy and in Table XIII. for Perennial Rye Grass.

The data for Timothy (Table XII.) are the most interesting, since the cutting dates came together on both systems. It will be noted (1) that the hay cut enormously exceeded the schedule (fifth) pasture cut falling on the same date. and (2) that the after-cuts were far in excess of the pasture cuts over the period August 1st to October 4th, this being particularly marked on August 28th, at which date the comparison was a perfectly direct and legitimate one, and it is evident, despite the fact that no after cut was taken on September 18th (thus favouring the after yield on October 4th) that the advantage would in any event have been with the after cuts during September and into early October.

The results for Perennial Rye Grass (Table XIII.) are chiefly of interest because they afford a comparison between pasture cuts initiated before and during the heading stage with each other, and with after cuts—unfortunately, however, the cutting schedule does not permit of complete and accurate comparisons at each of the cutting dates. The figures in the table afford evidence however, of the greater amount of produce developed during June, July, August and September by (1) the plants cut for the first time during heading stage, and by (2) those cut for the first time as hay, than by (3) those cut for the first time previous to heading stage. It is also apparent that the produce developed by the plants cut for the first time for hay was greater during July and early August than from those cut for the first time at the heading stage. There was,

* See (32), Table X., p. 30. At the time it was thought that the results might have been almost entirely due to the effects of the drought of 1921.

TABLE XII.—*To compare the yields from after with pasture cuts in the case of Timothy. Green weights in kilograms per 21 plants—two propagants of each plant being used for each of the two systems of cutting. The figures in round brackets constitute horizontal comparisons (as in previous tables) calculated on weights in decigrams.*

B. 98. 1922.

Cuts recorded and dates.	Pasture cuts.	Hay and after cuts.
Sum of the first three pasture cuts, April 27th—June 6th	1.88	—
The fourth pasture cut compared with the hay cut, July 11th	1.31 (100)	8.34 (637)
The fifth pasture cut compared with the first after cut, August 1st ..	0.86 (100)	1.48 (172)
The sixth pasture cut compared with the second after cut, August 28th	1.11 (100)	2.23 (200)
Sum of the seventh (18/9) and eighth, (4/10) last pasture cuts compared with the fourth (4/10) last after cut.	1.43 (100)	2.44* (170)

* No after cut was taken on September 18th, so that this figure represents growth from August 28th to October 4th, and therefore has a certain independent advantage over the sum of the seventh and eighth pasture cuts.

TABLE XIII.—*To compare the yields from after cuts with pasture cuts initiated* (a) *appreciably before, and* (b) *during the heading period in the case of Perennial Rye Grass. Green weights in kilograms per* 80 *plants, two propagants of each plant being used for each of the three systems of cutting. The figures in round brackets constitute horizontal comparisons (as in previous tables) calculated on weights in decigrams.* B. 91. 1922.

Cuts recorded and dates.	Pasture cuts initiated before heading period. 1st cut April 25th—27th.	Pasture cuts initiated during the heading period. 1st cut May 17th—19th.	Hay and after cuts.
Sum of the first two " before heading period " pasture cuts. April 25th—27th and May 16th—17th, compared with the first " heading period " pasture cut (May 17th—19th).	6.17 (100)	9.75 (157)	—
Sum of the third, fourth, fifth, and sixth "before heading period " pasture cuts (June 5th —August 11th) compared with sum of the second and third " heading period " pasture cuts (July 4th to August 10th) compared with the sum of the hay and first after cut (June 16th—August 15th).	17.14 (100) [6th cut = 4.54]* (100)	22.75 (132) [3rd cut = 9.35]† (205)	38.28 (223) [1st after cut = 14.00]‡ (309)
Sum of the seventh and eighth (last) " before heading period " pasture cuts (August 29th —September 29th) compared with the fourth (last) " heading period " pasture cut (September 21st—29th) compared with the third (last) after cut (September 21st—29th).	10.60 (100)	14.53 (137)	14.52 (137)

The range of cutting dates have not allowed of more detailed good comparisons than have been made in the Table.
* = August 10th—11th ; † = August 5th—10th ; ‡ = August 11th—15th.

however, no appreciable difference in productivity during the latter part of August and through September between the plants subjected respectively to these two systems of cutting—a fact which further emphasises the depressing effect of cutting before heading stage on subsequent productivity.

That Timothy and Perennial Rye Grass, both grasses that give very poor aftermath hay crops should have behaved in a manner similar to Cocksfoot (an excellent aftermath grass) affords particularly striking evidence of the greater productivity of after-grass than of late summer pasture grass.

The results as a whole would seem to suggest that more keep is to be expected during July, August and September from fields cut for hay than from those treated as pastures earlier in the season ; or, in other words, that at this time of the year, and even in normal years, after-grass should afford more abundant grazing than pastures. Farm practice indicates that this is in fact true—after-grass often being reserved for fatting purposes (supplemented, it is true, and rightly or wrongly by cake). A fuller realisation of the facts should undoubtedly tend in the direction of modifications in current practices relative to dates of " putting up " to and cutting for hay—over delay in both directions making for reduced after-grass.

(4) THE EFFECT OF CLOSENESS OF CUTTING ON THE GROSS YIELD FROM A SYSTEM OF PASTURE CUTS. In order to ascertain the influence of close cutting on yield certain plants of Cocksfoot were cut seven times, one set of propagants being cut to ground level (as nearly as possible) on each occasion, and a second set cut at 2-in. above the ground at each date. The results are given in Table XIV. (see column (5), the other data being referred to subsequently), from which it will be seen that the gross yield from the seven cuts at 2-in. was very appreciably greater than from the seven cuts taken at ground level.

It is thus evident that but a slight difference in the severity of cutting exercises a considerable influence on gross yield—and it would seem not improbable, therefore, that slight differences in severity of grazing would exercise an influence in a similar direction on temporary leys in their earlier stages.*

IV.—The Ratio of Stem to Leaf under Different Systems of Cutting.

In the previous sections regard has only been paid to gross yield ; it will now be necessary to examine the yields from different systems of cutting in terms of stem and leaf.† Unfortunately, it has only been possible to make stem and leaf analyses on an extended scale on single plants, and most of the data available have been obtained on Cocksfoot. Stem and leaf analyses have, however, been made on selected plots (on samples freed from weeds) representing a number of species grown in " tiller beds " (B.93). Analyses were made on the hay, the aftermath, and on selected pasture cuts. The results are given in Table XV.

It will be noted from the figures as a whole and particularly from the averages at the bottom of the table, that the aftermath contained an altogether

* For reasons previously explained (see p. 11), the cutting " to ground level " was in practice at a slightly higher level, so that the difference in severity between the two treatments was in fact somewhat less than the 2-in. aimed at.

† It is particularly important to have in mind the precise meaning attached to " stem " and " leaf " as used in this report and defined on p. 13.

Tablr XIV.—*To compare the gross yields from plants of Cocksfoot cut seven times when the plants were* (1) *cut to ground level, and* (2) *cut to the level of 2-in. above the ground. The weights of stem and leaf are shown separately and also the percentage of leaf in the aggregate produce. Results are given for plants cut twice in the previous year* (1922) *and for those cut seven times in the previous year.*

Dry weight in grams per plant, separate propagants of the same original ten plants being used for each treatment. Second harvest year, 1923. B. 108 III.

(1)	(2)	(3)	(4)	(5)	(6)
Pre-treatment adopted in 1st harvest year, 1922.	Treatment adopted in 2nd harvest (data) year, 1923.	Dry weight of stem.	Dry weight of leaf.	Total dry weight sum of seven cuts.	Percent. leaf in total produce.
Cut twice, hay and aftermath.	Cut 7 times. (16/3—20/9) Ground level.	23.4	85.1	108.5	78.4
	do. Two inches.	30.8	87.0	117.8	73.9
Seven pasture cuts.	do. Ground level.	19.6	63.6	83.2	76.4
	do. Two inches.	24.9	75.6	100.5	75.2

Table XV.—*To show the percentage of leaf in* (1) *the hay,* (2) *the aftermath,* (3) *the pasture cut taken at about the date of the hay crop, and* (4) *the pasture cut taken on July 16th—for a number of species and nationalities of grasses. The average percentage of leaf from all the above cuts is also shown, and for comparison the percentage leaf in the hay of* 1921 *from drills.*

Percentages based on dry weights from "Tiller Beds." Second harvest year. B. 93. 1923.

Species and nationality.	Percent. leaf in hay, 1921. 1st harvest year.	Percent. leaf in :— Hay.	Aftermath.	Pasture cut nearest hay date and date of cut.	Pasture cut July 16th.	Average of hay, aftermath and the two pasture cuts.
Cocksfoot Ind.	31	24	84	19/6 68	91	66
,, U.S.A.	22	18	91	14/5 40	95	61
Perennial Rye Grass, Ind. ..	30	21	94	,, 38	68	55
,, ,, ,, Com. ..	23	15	73	,, 21	67	44
Crested Dog's Tail agg.*	17	8	63	14/5 37	62	42
Tall Oat Grass, Ind.	39	27	84	19/6 62	83	61
,, ,, ,, French	17	11	41	14/5 37	62	38
Smooth St. M. Grass, comm.† ..	—	20	93	,, 40	96	61
Golden Oat Grass, comm.† ..	23	15	40	,, 40	56	37
Sweet Vernal Grass, Ind. ..	—	64	90	,, 34	81	67
Timothy, Ind.	68‡	30	59	16/7 43	—	—
Timothy, U.S.A.	43‡	18	—	19/6 28	50	—
Meadow Foxtail, comm.† ..	36	34	69	14/5 39	65	51
Tall Fescue agg.*	—	20	87	,, 60	90	64
Averages ..	26.5§	23.2	74.5	41.9	74.3	—

* No very appreciable difference between commercial and indigenous.
† The only nationality of which analyses are available.
‡ Quite exceptional, due to drought of 1921, see (32), p. 14.
§ Excluding Timothy.

higher percentage of leaf than the hay, while the pasture cut on July 16th, like the aftermath, was excessively leafy. It is of considerable interest to find that the pasture cut taken at about the same date as the hay cut contained a much lower proportion of leaf than other pasture cuts, indeed, in the case of certain species in particular (*e.g.*, commercial Perennial Rye Grass, commercial Timothy and Meadow Foxtail) the percentages of leaf in the pasture cut were but little more than in the hay, while with Sweet Vernal Grass the hay actually contained a considerably higher percentage of leaf than the pasture cut taken at hay period.

It is therefore evident in the case of the grasses that even under a system of pasture cuts they tend to produce stemmy (or hay-like) growth at the zenith of the growing season—this is, of course, well seen on ordinary pastures, which need to be grazed excessively hard from the middle of May until about the end of June to prevent any tendency to run to " bentyness " (stems and inflorescences). It is obvious from the figures for the pasture cut on July 16th (the fifth cut of a series of seven) that repeated cutting makes for a very leafy herbage, but that just as in the case of hay or aftermath the degree of leafiness varies over a fairly wide range for the different species.

It is to be noted that French Tall Oat Grass, French Golden Oat Grass and Crested Dog's Tail agg., which gave a very stemmy hay, gave aftermaths with a lower leaf to stem ratio than most other species, and also pasture cuts with a ratio less favourable to leaf than was the case with the majority of species, thus these species on the average of hay *cum* aftermath *cum* pasture cuts give a produce low in leaf. Commercial Perennial Rye Grass was but little better, but had given a fairly high contribution to the aftermath (always a poor yield). Amongst the most leafy grasses at all stages apparently, are Cocksfoot (especially indigenous), Sweet Vernal Grass, Tall Fescue (indigenous), Tall Oat Grass (bulbous var.), and Smooth Stalked Meadow Grass; indigenous Perennial Rye Grass and Meadow Foxtail, taking an intermediate position. The figures bear testimony to the greater average leafiness of the indigenous strains than of the non-indigenous, and are therefore in confirmation of the earlier results—this is particularly striking in the case of Tall Oat Grass and Timothy.

Comparison of the hay figures for 1921 and 1923 in all cases show the hay of the former year more leafy than that of the latter—which supports the view previously expressed that the droughty conditions of 1921 made for not only poor yields, but also for an unusually leafy hay.

Before considering the results from single plants it must be pointed out that such plants, growing as they were on continually hoed ground, appeared to maintain rather more luxuriant growth through the late summer and into the autumn than plants in sown drills or in tiller beds. Since the ratio leaf to stem becomes more and more in favour of leaf subsequent to hay period, it follows that with single plants repeatedly cut the ratio based on gross yield of leaf to gross yield of stem is likely to be rather exaggerated in comparison with that given by the produce of drills, tiller beds or broadcast plots, and similarly the yields at individual dates subsequent to the hay period are also likely to be accentuated. This must be borne in mind in relation to the evidence now to be discussed, which should be regarded as having a qualitative rather than a strictly quantitative bearing on the behaviour of young swards under different systems of cutting or of grazing.

The data available for single plants are presented in the form of aggregate yields in Table XVI.

TABLE XVI.—*To show the gross yield of stem and leaf respectively and the percentage of leaf in the aggregate produce from different systems of cutting.*

Dry weights in grams per single plant.

(1)	(2)	(3)	(4)	(5)	(6)
Expt. ref. and year.	Species.	Systems of cutting.	Weight of stem.	Weight of leaf.	Percent. leaf.
B. 108 I. 1921.	Cocksfoot agg.	three times *	75.6	74.3	49.5
	,,	seven ,,	27.6	57.9	67.7
	,,	ten ,,	14.1	41.7	74.5
	,,	seventeen ,,	5.6	24.5	81.3
B. 108 I. 1922.	Cocksfoot agg.	eight ,,	23.3	94.1	81.0
B. 108 III. 1923.	Cocksfoot ind.	three ,, *	140.8	130.5	48.1
		seven ,,	23.4	85.1	78.4
B. 72 II. 1923.	Tall Fescue agg.	twice *	116.7	90.0	43.5
		four ,,	27.8	52.5	65.5
B. 69 1923.	Sweet Vernal Grass agg.	twice *	67.9	47.2	41.0
		four ,,	60.3	42.6	41.4

* Starting with a hay and followed by one or two aftermath cuts, all the other cuts representing pasture systems.

The figures show that in proportion as the number of cuts is increased the percentage leaf contribution to the aggregate produce increases also—the completeness of the sequence will be more apparent (in the case of Cocksfoot, 1921), when it is stated that the leaf contribution in the hay of single plants averaged about 25 *per cent.* It will be noted (Cocksfoot) that systems involving from seven to seventeen cuts per annum developed an excessively leafy produce, but that the actual yield of leaf as such was in all cases very much less than that given by the sum of a hay and two aftermath cuts, till under seventeen cuts the yield of leaf was less than 1/3 of that given by three cuts. It follows from the increasingly high percentage of leaf under drastic cutting that the falling off in gross yield of stem and leaf together under systems of oft-repeated cutting is primarily due to a far greater diminution in stem than in leaf, and this is well shown in column 4 of the table—the yield of stem under seventeen cuts (Cocksfoot), for instance, being hardly 8 per cent. of that developed under three. Tall Fescue has behaved in a manner similar to Cocksfoot ; Sweet Vernal Grass, on the other hand, has given very similar yields and very similar stem to leaf ratios from hay *cum* aftermath and from a system of four pasture cuts ; this would seem to be accounted for by the particularly leafy hay and aftermath given by the grass, and by the fact previously alluded to that the pasture cut at about hay time tends to be surprisingly stemmy. It will be seen from Table XV. that on the average of all systems of cutting indigenous Cocksfoot was more leafy than non-indigenous, this being most marked in the hay. The leaf to stem ratio appears, however, to become more favourable to indigenous under pasture systems in proportion as the number of cuts is increased, as the following figures for percentage leaf in the aggregate produce from different systems show :—

Expt. Ref. and Year.	No. of cuts.	Percentage leaf in aggregate produce.	
		Indigenous.	Non-indigenous.
B.108 I. 1921	Seven } relatively lenient.	68	66
B.108 I. 1922	Eight } relatively lenient.	88	82
B.108 I. 1921	Seventeen—drastic.	86	76

This is what is to be expected having regard to the fact that indigenous have been shown to resist drastic cutting better than non-indigenous—the former maintain better growth throughout the season under these conditions than the latter, and therefore produce more herbage during the "leafy periods" of the season, this of course reacting on the percentage of leaf in the aggregate produce.

The relation of stem to leaf throughout the season under different systems of cutting is most easily demonstrated by plotting the yields for each separately against the cutting dates. This has been done in the case of Cocksfoot under a system of three cuts (1921, see Figure VII.); under a system of five cuts (1923, see Figure VIII.); under a system of seven cuts (1921, see Figure IX.); under a system of ten cuts (1921, see Figure X.); and under a system of seventeen cuts (1921, see Figure XI.). It is perhaps unfortunate that the most complete data were obtained during dry 1921, but it can hardly be open to doubt that qualitatively considered the results have a very general application.

FIGURE VII.—*To show the yield of stem and leaf separately in each of three cuts, hay, first aftermath and second aftermath for Cocksfoot agg.*

Yields in decigrams (dry matter) per single plant. B. 108. I. 1921.

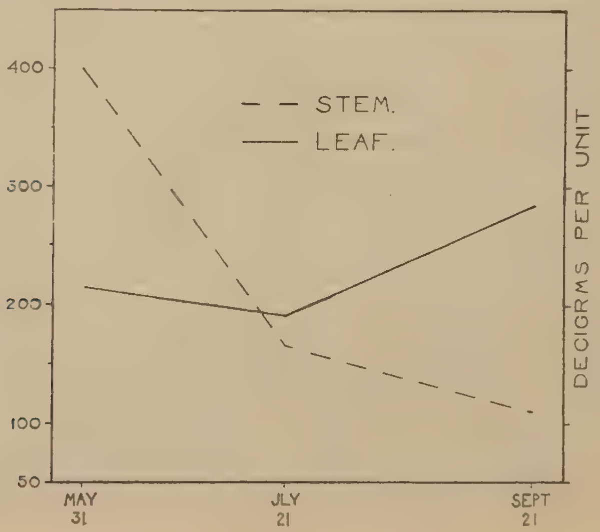


FIGURE VIII.—*To show the yield of stem and leaf separately in each of five cuts (first cut taken in March) for Cocksfoot agg.*

Yields in decigrams (dry matter) per single plant. B. 56. II. 1923.

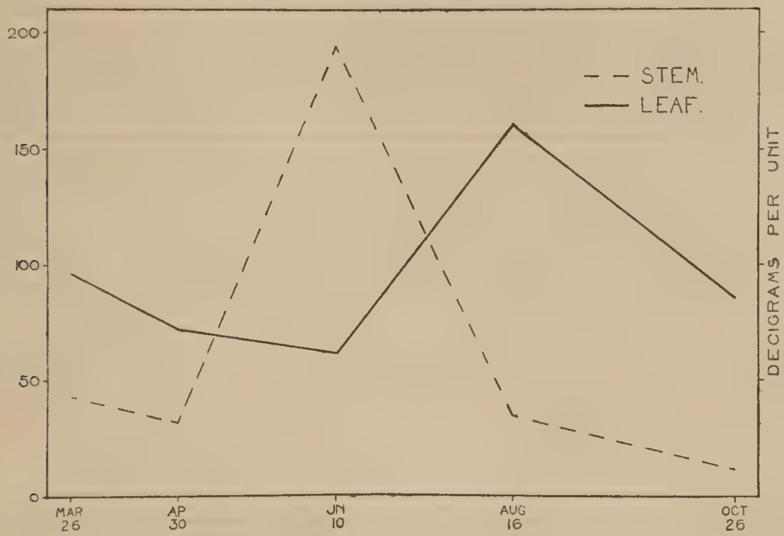


FIGURE IX.—*To show the yield of stem and leaf separately for each of six pasture cuts (the first cut of the season being ignored) for Cocksfoot agg.*

Yields in decigrams (dry matter) per single plant. B. 108. I. 1921.

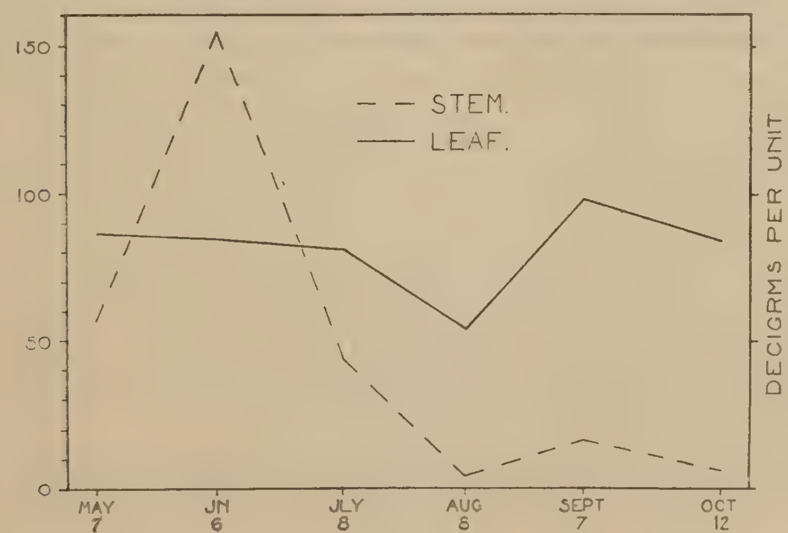


FIGURE X.—*To show the yield of stem and leaf separately for each of nine pasture cuts (the first cut of the season being ignored) for Cocksfoot agg.*

Yield in decigrams (dry matter) per single plant. B. 108. I. 1921.

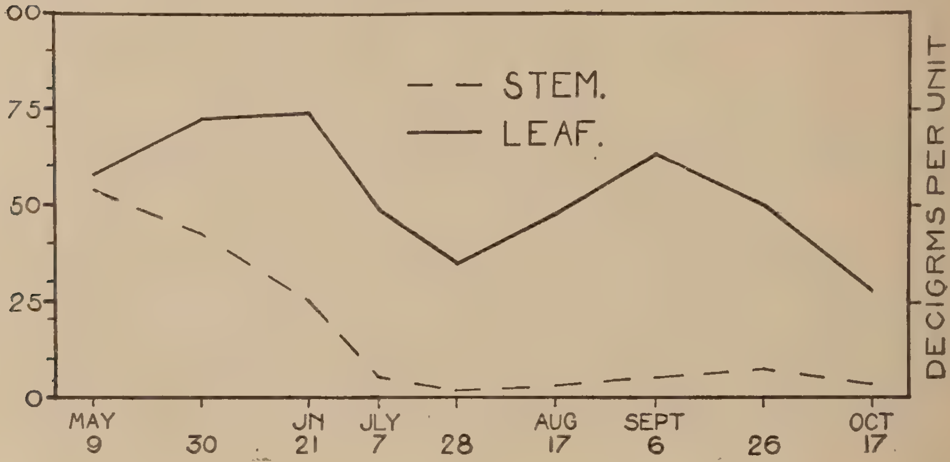
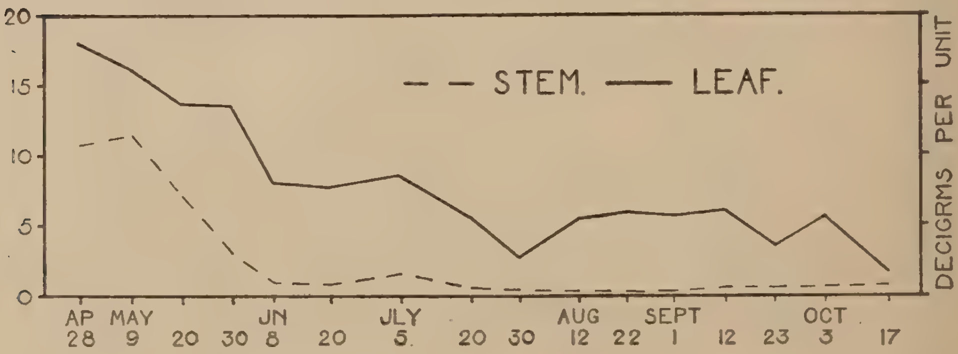


FIGURE XI.—*To show the yield of stem and leaf separately for each of sixteen pasture cuts (the first cut of the season being ignored) for Cocksfoot agg.*

Yield in decigrams (dry matter) per single plant. B. 108. I. 1921.



A comparison of the five Figures shows that repeated cutting tends to diminish stem development far more than leaf developnemt *at all dates.* Under drastic cutting (ten and seventeen times), excluding the first cut from consideration, it will be noted that leaf has actually given higher yields than stem throughout the whole season—under the most drastic system (17 cuts) stem fell to almost negligible productivity as early as June 8th, and never recovered ; under a ten cut system it dropped to insignificance by July 7th. The ten and seventeen cutting systems were drastic enough to prevent stem developing a primary peak at hay period, under ten cuts the fall in stem was steadied during hay period, while under seventeen cuts a uniform depression had developed even prior to the hay period, and under both systems no appreciable secondary peak showed itself during aftermath period. It is interesting to note that under ten cuts leaf was able to develop well marked primary and secondary peaks, while under seventeen cuts the curve was much flattened, and but little differential response was possible either to the influences of functional periodicity or of meteorological conditions.

The curve for monthly cuts (seven cut system) indicates that under this less drastic treatment the plants were alike responsive to functional periodicity and meteorological conditions. Stem gave a well marked primary peak at hay period, when it out-yielded leaf by a considerable margin, but soon gave place to leaf—although a quite definite secondary peak revealed itself. Late in the season when the beneficial influences of rain were realised it was, however, leaf that was alone able to respond to a really appreciable extent.

It will be seen by reference to Figure II. in the article dealing with the chemical composition of the grasses (see p. 94) that under a system of nine cuts in 1922 the stem again gave a well marked primary peak at hay period (May 30th) when in the case of two of the nationalities it out-yielded leaf, and in this year gave a more considerable secondary peak (on August 22nd) than in 1921. It is of chief interest, however, to compare the behaviour of leaf in the two years—(compare Figures VIII. and IX. with Figure I., p. 28). In 1922 leaf did not reach maximum productivity until August 22nd, and thus actually gave a considerably higher yield during August and early September than in May and June.

Reference to Table XIV., comparing cutting to ground level with cutting to 2-in. shows that the more drastic method has influenced the development of leaf less than that of stem ; the ratio leaf to stem being higher under the former than the latter treatment, though the actual amount of leaf obtained from the sum of the eight cuts was greatest in the case of the propagants cut to two inches.

In the case of Red Clover cut eight times (monthly) it is to be noted that the ratio leaf to stem in the aggregate produce of the cuts, and at most of the cutting dates stands, considerably higher than with the grasses. Reference to Table X. (p. 144) in the article on Red Clover shows that at no date did the percentage leaf fall below 70 *per cent.* for any of the strains under test, and during May some of the strains gave leaf contributions of as much as 97 *per cent.*

Both the " three cut " (Figure VII.) and " five cut " (Figure VIII.) systems illustrate the predominance of stem in the hay and of leaf in the aftermath and after-grass ; Figure VIII. demonstrating the fact that the early (*i.e.*, pre-heading) herbage is predominantly leafy whether developed under a system of few or many cuts, while all the Figures show that despite the systems of cutting

adopted the post-hay herbage also tends to be predominantly leafy. An important point brought out by Figure VIII. (five cuts) in particular, and to a lesser extent by Figure VII (three cuts), is the excessive leafiness of the herbage in the aftermath and after-grass, and also the high yield of leaf as such compared with that developed in the hay and pre-hay period, and also compared with the leaf developed in the same (post-hay) period from a system of seven cuts.

The graphs shown in Figures VII.—IX., compared with the data obtainable under Lindhard's scheme of separation into "stem shoots" and "leaf shoots" respectively indicate the great advantage of making the "stem" and "leaf" separations as here defined. In the case of Cocksfoot even when cut seven times (see Figure IX.) a definite though small amount of "stem" was revealed even in the last three cuts—while Lindhard found (under but a six cut system) that his last three cuts consisted wholly of "leaf shoots."* The importance of being able to differentiate between stem and leaf accurately and throughout the whole season and the supreme significance of the stem to leaf ratio will be rendered the more apparent after perusal of the subsequent article on the chemical composition of the grasses. The practical implications of the results here dealt with will therefore be discussed in the last article of this bulletin.

V.—The Relation of Percentage Dry Matter in Green Fodder to Seasonal Productivity.

It follows from the results so far considered that the ration presented to grazing animals at any particular time must be exceedingly variable as between field and field and equally variable from time to time on one and the same field, in respect of the stem to leaf ratio.

The figures as to percentage dry matter in the produce obtained at selected cutting dates on a system of pasture cuts for a number of species given in Tables XVII. and XVIII., suggest that the ration must be equally variable in respect of the ratio water to dry matter. An interesting point brought out by the data for both 1922 and 1923 (see average figures at the bottom of the tables) is the fact that the percentage dry matter tends to be low (at its lowest in 1923) during the period of maximum growth (May and June); this was also the case in 1921, in which year maximum growth took place unusually early. Thus in a general way maximum yield of dry matter tends to be associated with minimum or approaching to minimum per centage of dry matter in total dry produce. This is even more marked in the case of Red Clover. It has been shown in the article dealing with that species (see p. 139 and in particular Figure II), that there is a quite definite negative correlation between percentage dry matter and total yield. It is evident, therefore, that just as yield as such and the ratio stem to leaf at incremental periods throughout the season are largely determined by the plant's functional periodicity, so is the ratio water to dry matter in the green fodder. The percentage of water in the produce is, however, also largely influenced by meteorological conditions, this is well shown by comparing the percentage dry matter obtained during 1921 with that during 1922. The comparisons made hereunder are not absolute, because based on analysis made

* See figures quoted on p. 17.

TABLE XVII.—*To compare the percentage dry matter in green fodder at selected periods in a system of pasture cuts and to compare the percentages with dry yield for the same periods. Eleven species cut 6 times during 1922.*

B. 93.

Species, nationality and strain.	Average of cuts on May 5th and June 5th.		Cut on July 3rd.		Average of cuts on July 31st and Aug. 31st.		Cut on Sept. 30th.		Average per cent. dry matter from all cuts separately.
	Weight in grams of dry matter.	Per cent. dry matter in green fodder.	Weight in grams of dry matter.	Per cent. dry matter in green fodder.	Weight in grams of dry matter.	Per cent. dry matter in green fodder.	Weight in grams of dry matter.	Per cent. dry matter in green fodder.	
Cocksfoot, Indigenous ..	143.2	25.70	48.6	36.00	49.5	18.17	22.6	23.74	24.56
,, U.S.A. ..	132.2	23.33	43.7	32.82	49.1	21.11	17.4	25.19	24.48
Perennial Rye Grass, Ind.	106.3	24.21	60.9	29.00	44.5	20.09	36.9	23.79	23.57
,, ,, ,, Dan.	134.5	23.02	29.1	29.72	39.6	19.86	44.4	25.38	23.48
Timothy, Indigenous ..	80.0	28.13	20.6	34.39	35.7	26.31	28.9	27.56	28.47
,, U.S.A. ..	107.4	28.28	5.7	33.70	23.8	22.04	11.4	26.50	26.81
Tall Oat Grass, Ind. ..	39.0	24.52	11.2	41.08	26.0	22.63	16.5	27.47	27.14
,, ,, ,, French ..	77.3	23.64	10.0	36.82	22.8	22.50	13.2	24.09	25.53
Golden Oat Grass, Ind. ..	64.8	25.03	22.3	31.79	30.8	21.03	36.1	25.82	24.95
Crested Dog's Tail, Ind. ..	63.1	31.02	21.1	32.50	30.2	26.56	30.6	23.89	28.59
Red Fescue ,, ..	61.2	27.63	35.8	35.48	34.2	22.06	28.1	28.09	27.16
Meadow Fescue ,, ..	83.6	25.54	62.7	27.40	47.6	23.00	32.2	23.00	24.58
Tall Fescue ,, ..	83.2	24.54	75.1	33.25	39.2	26.60	23.2	27.30	27.14
Meadow Foxtail ,, ..	116.9	26.23	52.1	25.18	44.1	23.12	25.8	25.77	24.94
R.S. Meadow Grass* Ind.	47.8	30.23	15.6	39.89	22.1	25.47	33.4	28.75	30.01
Average for all species and strains	89.27	26.0	34.3	33.2	35.9	22.7	26.7	25.7	26.09

* The least weedy plot selected, but results possibly influenced by weeds.

TABLE XVIII.—*To compare the percentage dry matter in green fodder at selected periods in a system of pasture cuts, and to compare the percentages with dry yield for the same periods.* Ten *species cut* 8 *times during* 1923.

B. 93.

Species and nationality.	Average of cuts, November 11th, 1922, Jan. 15th, Mar. 15th.		Average of cuts, May 14th and June 19th.		Average of cuts, July 16th, Aug. 15th, and Sept. 18th.		Average per cent. dry matter from all cuts separately.
	Weight in grams of dry matter.	Per cent. dry matter in green fodder.	Weight in grams of dry produce.	Per cent. dry matter in green fodder.	Weight in grams of dry produce.	Per cent. dry matter in green fodder.	
Cocksfoot, Indigenous	23	29.09	124	23.00	43	23.76	25.57
Cocksfoot, U.S.A.	20	30.95	99	21.25	31	27.06	27.07
Perennial Rye Grass, Ind. ..	42	31.04	35	21.17	31	27.10	27.09
,, ,, ,, Danish ..	27	30.28	76	25.75	21	27.31	28.03
Timothy, Indigenous	11	37.39	35	24.95	21	32.86	32.58
,, U.S.A.	14	42.41	92	25.99	12	36.66	36.15
Tall Oat Grass, Indigenous ..	12	27.02	68	22.26	12	32.64	27.94
,, ,, ,, French	18	28.29	81	24.02	24	31.75	28.52
Golden Oat Grass, Indigenous ..	16	32.16	69	24.44	28	30.75	29.70
Crested Dog's Tail ,, ..	21	35.50	68	28.10	22	28.02	30.85
Red Fescue ,, ..	13	28.24	40	28.47	28	28.21	28.29
Meadow Fescue ,, ..	20	33.43	80	23.66	34	26.13	28.25
Tall Fescue ,, ..	15	32.51	69	25.05	30	28.54	29.16
Meadow Foxtail ,, ..	31	32.88	119	22.27	31	31.54	29.72
Average for all species and strains	20.2	32.23	75.4	24.31	26.3	30.0	29.19

separately on stem and leaf.* The figures for leaf (the chief contributing element) were, however, as follows in the case of Cocksfoot, based on the aggregate produce from four systems of cutting in each case :—

In 1921 percentage dry matter in green leaf—27.2 per cent.
,, 1922 ,, ,, ,, ,, ,,—23.5 ,, ,,

A more interesting comparison is that between the percentage dry matter in leaf in July in the two years, the effect of the drought of 1921 being at its maximum in that month :—

In July, 1921 percentage dry matter in green leaf—32.2 per cent.
,, 1922 ,, ,, ,, ,, ,,—23.0 ,, ,,

The above figures suggest that the high dry matter content in July, 1921, was due not so much to low rainfall as such at the time, but to the starved condition of the plants at that period, pre-determined by the foregoing drought, which rendered growth almost negligible—thus the meteorological conditions had had a secondary rather than primary influence.†

The results given in Tables XVII. and XVIII. cannot be compared with those given above, because in the first place the percentage dry weights have been obtained on total produce and are correct percentages, and in the second, because the tiller beds involved had not been well established. On account of this latter fact the results for 1922 and 1923 cannot be critically compared, for in the latter year the plants were less vigorous than in the former, also the cutting systems were different, consequently the fact that the average dry matter contribution (based on all the cuts) for all the species was slightly higher in very wet 1923 than in relatively dry 1922 is not significant. The following figures however, are, significant in relation to the critical periods above referred to, and to those dates when the difference between the meteorological conditions of the two years (1922 and 1923) would have been in greatest evidence, and are in confirmation of the comparisons made between 1921 and 1922 :—

At maximum growth period in 1922 : average percentage dry matter in produce for all species	26.0 per cent.
At maximum growth period in 1923 : average percentage dry matter in produce for all species	24.6 per cent.
July 3rd, 1922, average percentage dry matter in produce for all species..	33.2 per cent.
July 16th, 1923, average percentage dry matter in produce for all species..	29.7 per cent.

It is thus evident that the dry matter content of green grass under a system of pasture cuts always tends to be low in May and towards the middle of June and high in late June or in July, the precise dates of the lowest and highest contributions and the precise percentages attained to being alike largely determined by the meteorological conditions obtaining from the commencement of the growing season. The percentage dry matter in the produce is also influenced by the condition of the herbage, and therefore by the number of cuts. Under a system

* See p. 14 for the reservations that have had to be made in relation to the dry matter determinations on the plants here considered. The figures, however, may be assumed to be accurate if regarded merely as a ratio, which is all that is required in this connection.

† It has been previously explained that 1921 was evidently physiologically much drier than 1922.

of but few cuts much nearly adult, and much old partially or wholly non-functionary herbage will be taken—herbage at least some of which will be dead or dying (and therefore drying)—thus the percentage of dry matter in the aggregate produce will on this account alone tend to be high, while under a system of many cuts all the herbage taken will be young and functioning. The herbage from towards the middle or end of October until well into March will also tend to be much burned (and therefore dried), and this tendency will be at its greatest the fewer the cuts. Thus the particularly high percentage of dry matter given in November (1922), January and March 1st (1923), (see Table XVIII.) was not only due to growth being at a low ebb, but to the presence of dried or partially dried, dead or partially dead, "burned" herbage. Data are only available for comparing few to many cuts for 1921, when the percentage of dry matter was, as before explained, obtained on stem and leaf separately. Comparison can be made for leaf on a seven and seventeen cut system respectively (the separations were quickly performed in these cases). The aggregate green leaf from seven cuts contained 28 *per cent.* dry matter, and that from seventeen cuts 25 *per cent.*

The percentage of dry matter in the produce from a two cut system, hay *cum* aftermath (B.93), for 1922 and 1923 is given for each cut separately in Table XIX. It will be seen that both in respect of hay and aftermath the dry matter stood at a higher ratio to green fodder in relatively dry 1922 than in very wet 1923.* The green fodder taken as hay, and on the average of both years and for all the species, contained nearly ten *per cent.* more dry matter than the green fodder taken as aftermath.

TABLE XIX.—*To compare the percentage dry matter in green fodder when taken respectively as hay and aftermath for the two years* 1922 *and* 1923. *Ten species of grasses.* B. 93.

Species and nationality.	Percentage dry matter in green fodder.			
	In hay.		In aftermath.	
	1922	1923	1922	1923
Cocksfoot Indigenous	39.25	28.76	26.77	23.13
,, U.S.A.	37.75	29.48	27.86	24.48
Perennial Rye Grass, Ind.	36.98	31.65	24.70	26.46
,, ,, Danish	37.40	31.79	29.81	25.50
Timothy, Indigenous	35.79	34.19	30.60	25.78
,, U.S.A.	35.98	35.50	24.39	34.36
Tall Oat Grass, Indigenous	35.72	30.59	27.68	26.85
,, ,, ,, French	40.23	31.85	28.20	24.22
Golden Oat Grass, Indigenous ..	37.14	34.20	26.58	26.47
Crested Dog's Tail ,, ..	29.82	33.28	28.32	29.19
Red Fescue ,, ..	58.16	37.17	29.07	24.92
Meadow Fescue ,, ..	32.99	29.98	24.82	25.38
Tall Fescue ,, ..	37.33	34.82	25.77	26.74
Meadow Foxtail ,, ..	43.68	36.38	27.19	26.84
Average for all species and nationalities	38.44	32.83	27.27	26.31

* Here the comparison was between quite similar cutting systems in both years.

Sutton and Voelcker's (28) data show a very similar relationship, the percentage dry matter in hay from permanent sward cut at the proper time was 32.5 per cent. (that cut at the heading stage was 24.8 per cent.), and the percentage of dry matter in the aftermath was 24.5 per cent. The figures quoted thus confirm the view generally held to the effect that the green fodder in the aftermath is very much more watery than that in the hay crop when taken at the proper time, and indicates the much higher percentage of dry matter to be obtained from the aggregate produce of but two cuts than from that given by a system of pasture cuts ; a three cut system similarly would be dominated by the dry matter given in the hay.

In so far as individual species are concerned the figures from pasture cuts in 1922 and 1923 (Tables XVII. and XVIII.) do not show any marked or consistent difference between indigenous and non-indigenous strains in respect of percentage dry matter. There will be seen to be a considerable variation between the several species, Timothy, Crested Dog's Tail, and Red Fescue giving rather uniformly high percentages of dry matter to total green produce.

When judged by hay and aftermath (Table XIX.) there is again no constant or considerable difference between indigenous and non-indigenous strains as such. Red Fescue on the average of the two years, as under pasture, gave a high dry matter ratio. Indigenous Golden Oat and Crested Dog's Tail, also with high dry matter contributions under pasture, were not, however, above the average in respect of hay and aftermath. Meadow Foxtail, particularly in 1922, has given very high dry matter ratios in both hay and aftermath, this would, however, be sufficiently accounted for by its early maturity.

Since it has been shown that cutting dates and conditions have such a considerable influence on the ratio under consideration, it is obviously necessary to conduct particularly critical trials over a great number of years before it would be possible to make really accurate and legitimate comparisons between different species or between different strains of the same species.

VI.—Comparison of the effect of cutting often, with that of cutting but two or three times on the Tiller and Root development of the plants so cut.

Having shown the effect of various systems of cutting on the productivity and other characteristics of plants during the season of cutting, it is desirable to enquire whether at the end of the season any further effects may have shown themselves on the nature of the plants differentially cut, and whether some cause can be found for the reduced yields under a drastic system of pasture cuts.

Kraus (14) in Germany has shown in the case of a number of herbage species that plants cut no more than four times during the growing season will have produced by the end of the season much less weight of roots than plants cut but once—while in America McKee (17) has shown that clipping Lucerne in the seeding year retards root development in the first harvest year, and more recently Graber (9) has demonstrated that Lucerne leys frequently cut are less persistent than those cut but two or three times a year.

A large number of the single plants under test have accordingly been carefully dug up at the end of the cutting season or before growth commenced in the following season. The roots have been washed out, dried and weighed, and the number of tillers counted. A summary of the data thus obtained is set out in Table XX.

TABLE XX.—*To show the effect of different systems of cutting on the root and tiller development of the plants so cut.*

Data obtained on plants subjected to cutting in 1921 (very dry), 1922 (dry spring, wet later), and 1923 (very wet).

Species of plant and experiment reference.		No. of times cut during the growing season and year of cutting.	Wt. of roots per single plant at end of cutting period. In grs. dry wt.	No. of tillers per single plant at end of cutting period.
Cocksfoot agg. ..	B. 108 I.	Cut 3 times, 1921 ..	14.3	180
,,		,, 10 ,, ,, ..	2.4	72
,, ...		,, 17 ,, ,, * ..	1.2	32
,, ...	B. 56 I.†	,, twice 1922 ..	20.2	419
,, ...		,, 8 times ,, ..	7.6	308
,, ...	B. 108 II.	,, twice 1922 ..	22.0	286
,, ...		,, 8 times ,, ..	6.2	155
,, ...	B. 108 I.	,, twice 1922 ..	40.2	296
,, ...		,, 8 times ,, ..	8.9	177
,, ...	B. 56 I.†	,, 3 times 1923 ..	22.0	279
,, ...		,, 7 ,, ,, ..	12.0	211
Tall Fescue agg. ..	B. 70 I.†	,, twice 1923 ..	24.0	301
,, ...		,, 4 times ,, ..	16.0	194
Sweet Vernal Grass agg.	B. 69†	,, twice 1923 ..	17.4	800
,, ...		,, 4 times ,, ..	10.7	500

* Two plants killed by the end of the season.

† Propagants of the same groups of plants having been used for both systems of cutting.

It will be noted that in all cases plants cut four times and upwards have shown a very considerable reduction in both root system and in tillers over those cut but twice or three times, but that the greatest damage occasioned by oft-repeated cutting was during dry 1921, when cutting 17 times actually killed two plants outright and reduced the roots and tillers of all to relative insignificance.

It is thus apparent that grasses are exceedingly liable to actual physiological injury by a vigorous treatment of cutting, and it is to be expected that the damage to the root system would have begun to be felt soon enough to influence adversely the aggregate yield obtained during the season of drastic cutting. Since grasses are perennial by virtue of their capacity for the production of new tillers and new roots every year recuperation may be expected to be rapid during the season following cutting, provided the plants had not been killed or nearly killed. The facts given hereunder obtained from results obtained with Cocksfoot (B.108 II.) are of interest in this connection.

In the case of a batch of 32 plants cut nine times during 1922, the average dry weight of root per plant on sixteen plants dug up early in 1923, was 6 grammes, and the number of tillers 150, while with the other 16 plants allowed to grow on and recuperate until August 17th, 1923, the root weight had then become

19 grammes (from 6), and the number of tillers 263 (from 150). Thus recuperation had been considerable, but that it had been far from complete is indicated by the fact that a batch of 13 plants cut only twice during 1922 and then allowed to grow on until August 17th, 1923, gave an average root weight of 28 grammes (as opposed to 19 grammes for the plants recuperating from the severer 1922 treatment).

The effect of repeated cutting on the root and tiller development of indigenous and non-indigenous strains of Cocksfoot respectively is compared relatively in the statement hereunder :—*

	Cut three times in 1921 and in 1922.		Cut seven times in 1921, and eight times in 1922.	
	Roots.	Tillers.	Roots.	Tillers.
Indigenous	100	100	28	71
Non-indigenous	,,	,,	29	51
			Cut 17 times in 1921, and 8 times in 1922.	
Indigenous	,,	,,	19	42
Non-indigenous	,,	,,	20	47
	Cut three times in 1923.		Cut seven times in 1923.	
Indigenous	100	100	57	79
Non-indigenous	,,	,,	52	71

It will be apparent that relatively both nationalities have suffered to about an equal extent in the matter of root system. Except under the most drastic system of cutting the indigenous have suffered less than the non-indigenous in respect of tiller development, and of course by virtue of the far larger average number of tillers per plant the indigenous have actually shown to much the better advantage. Under the most drastic system both nationalities suffer severe damage, the indigenous actually (by virtue of the much larger number of tillers) withstanding the treatment best—but showing slightly the greater relative damage based on percentage tiller reduction from a three cut system.

VII.—The effect of Pre-Treatment (exercised by different systems of cutting) on Productivity.

It now remains to enquire whether the adverse effect on root and tiller development exercised by repeated cutting translates itself in terms of reduced yield during the season following the treatment, and whether any effects last into subsequent seasons.

(1) EFFECTS DURING THE SEASON IMMEDIATELY FOLLOWING THE TREATMENT. Since it has been shown that root injury is very severe under drastic cutting, and that recuperation is far from complete during the season following the treatments, it is to be expected that reduced yields would show themselves particularly early in the year of recuperation. A large amount of data has been collected on this point. The most important results are given in Tables XXI. and XXII for single plants, and in Tables XXIII., XXIV., XXV. and XXVI. for drills. The seasonal effects of pre-treatments have been shown by resort to graphs—see Figure III. (p. 29) and Figures XII. and XIII.

* B.108. I, II and III.

TABLE XXI.—*Data for Cocksfoot from single plants. To show the effect of various systems of cutting adopted in the first harvest year, on the yield and leafiness of the produce obtained in the second harvest year.*

Weights per single plant.

A.—PRE-TREATMENTS IN DRY 1921. (B. 108 I.).

Pre-treatments adopted in 1st harvest year 1921.	Data obtained in the 2nd harvest year (1922) on all plants cut on a uniform plan, namely, 8 times (monthly) during the said 2nd harvest year.			
	Dry weight of stem and leaf together in grs. from single cut, April 27th.	Percent. leaf in cut April 27th.	Dry weight stem and leaf together in grs. given by the sum of the 8 cuts.	Per cent. leaf in produce of the 8 cuts together.
Cut 3 times (5)	9.1	83.0	113.7	79.0
Cut 7 times (10)	3.5	84.0	87.2	79.0
Cut 10 times (6)	2.8	86.0	99.2	82.7
Cut 17 times (8	0.4	86.0	49.2	85.3

B.—PRE-TREATMENTS IN DRY-EARLY-WET-LATE 1922. (B. 108 II.).

Pre-treatments adopted in 1st harvest year, 1922.	Data from a single cut made on April 11th, 1923. Dry weight of stem and leaf together in grams.
Cut 3 times (13)	21.9
Cut 9 times (30)	6.9

The figures in brackets indicate the number of plants contributing to the averages for each system of cutting.

The results obtained with single plants have a special interest, because they have been supported by stem and leaf separations.

It will be seen from Table XXI. that pre-treatments adopted in 1921 have had a profound influence on the yield obtained during 1922. Under the lenient pre-treatment of but three cuts the yield early in the subsequent season (April 27th, 1922) was nearly twenty-four times greater than under a drastic pre-treatment of seventeen cuts, while the gross produce for the whole season was over twice as much after the most lenient than after the most drastic pre-treatment. It will be noted also that the difference between seven and ten pre-cuts were not nearly as great as that between three and seven or between ten and seventeen. Comparing the results of pre-treatments adopted in 1921 (see "A" of Table XXI.) with those from pre-treatments adopted in 1922 (see "B" of Table XXI.) it will be seen that although the yields early in 1923 were greater than those early in 1922—yet relatively (comparing pre-treatment "three cuts" with "ten cuts" in 1921 with pre-treatment "three cuts" with "nine cuts" in 1922) the reduction in the spring following had been

practically the same in each year; namely as 100 to 31.6 for the 1921 pre-treatments and as 100 to 31.5 for the 1922 pre-treatments. It is thus evident that the results following pre-treatments in 1921 were by no means entirely or even chiefly due to the exceptional conditions of that year. The data for Sweet Vernal Grass and Tall Fescue (Table XXII.) also show substantial reductions from pre-treatments initiated in 1922. Tall Fescue suffered far more than Sweet Vernal Grass under severe pre-treatment, the ratio *pre-cut three times* to *pre-cut eight times* being for the former grass 100 to 24.1 and for the latter 100 to 40.2. Reference to the tiller and root data show, moreover, that Sweet Vernal Grass maintained a much better development of both tillers and roots under a system of eight pre-cuts followed by four cuts in the next season (compared with two pre-cuts followed by four cuts) than did Tall Fescue under like conditions.

TABLE XXII.—*Data for Sweet Vernal Grass and Tall Fescue per single plant. To show the effect of different pre-treatments adopted in the first harvest year* (1922) *on yield and other characteristics of the plants in the second harvest year* (1923).

Weights per single plant.

Species and experiment	Pre-treatment in 1922.	Data obtained in second harvest year, 1923.			
		Sum of four six-weekly cuts in grs. dry wt. stem and leaf together.	Per cent. leaf.	No. of tillers at the end of the season.	Wt. of roots at the end of the season in grs. dry weight.
Sweet Vernal Grass, B. 69 (12)	Cut twice.	72.9	58	500	10.7
	Cut 8 times at 3 weekly intervals.	29.3	68	387	8.9
Broad Leaved Fescues, B. 70 I. (24)	Cut twice.	58.3	60	197	16.0
	Cut 8 times at 3 weekly intervals.	14.1	70	75	6.8

It is of considerable interest to note that the effect of pre-treatment on the stem to leaf ratio is similar in kind to the effect of treatment during a current season. Thus the aggregate produce following a severe pre-treatment tends to have a slightly higher leaf to stem ratio (in the case of Cocksfoot) than the produce following a lenient pre-treatment; while in the case of Sweet Vernal Grass and Tall Fescue the ratio following severe treatment is even more markedly in favour of leaf. It follows, therefore, that both in respect of quality and quantity the produce developed is influenced to a considerable extent by pre-treatment.

Reference to Table XIV. (p. 48) indicates that cutting to ground level following a pre-treatment of seven cuts (also to ground level) shows a greater

TABLE XXIII.—*To show the effect of various systems of cutting adopted in the first harvest year* (1922) *on the weight of produce developed in the second harvest year* (1923). *The data obtained in the second harvest year were from a system of* 8 *pasture cuts. The figures in square brackets constitute vertical comparisons, and those in round brackets horizontal comparisons, as in previous tables* (*see text*).

Green weights in ozs. per row of 20ft. Cocksfoot B. 60.

Nationality and strain.	Pre-treatment (in 1922).								
	Lenient : Hay and aftermath (2 cuts).			Intermediate : Monthly pasture cuts (10 cuts).			Drastic : Fortnightly pasture cuts (20 cuts)		
	Yields in second harvest year (1923).								
	Sum of 2 cuts, Mar. 10 and 29	One cut May 24.	Sum of 8 cuts.	Sum of 2 cuts, Mar. 10 and 29	One cut May 24.	Sum of 8 cuts,	Sum of 2 cuts. 10 and 29 Mar.	One cut May 24.	Sum of 8 cuts.
Indigenous tussocks ..	26.7 [100] (100)	48.1 [100] (100)	201.6 [100] (100)	21.0 [100] (78)	29.3 [100] (61)	175.9 [100] (87)	8.7 [100] (32)	15.8 [100] (32)	105.1 [100] (52)
,, dense pasture	18.9 [70] (100)	42.4 [88] (100)	183.0 [90] (100)	13.9 [66] (73)	29.7 [102] (70)	172.1 [97] (94)	7.9 [90] (42)	10.2 [64] (24)	112.7 [107] (61)
,, open	21.5 [80] (100)	42.6 [89] (100)	194.6 [96] (100)	15.3 [73] (71)	25.5 [87] (59)	152.2 [86] (78)	4.9 [56] (22)	11.5 [73] (27)	89.9 [85] (46)
Danish *cum* U.S.A. ..	32.0 [120] (100)	58.6 [121] (100)	190.1 [94] (100)	19.3 [91] (60)	41.8 [143] (71)	160.7 [91] (84)	7.0 [80] (22)	15.0 [95] (23)	83.6 [79] (43)

relative reduction in yield compared to cutting at two inches after such a pre-treatment (seven cuts to ground level) than when both cutting to ground level and to two inches follows a pre-treatment of but two cuts.

The results obtained from drills afford material for comparing the effects of pre-treatment on indigenous and non-indigenous strains respectively; the data available from single plants show, however, that severe pre-treatments react on the leaf to stem ratio more markedly in the case of indigenous than non-indigenous. The comparative statement hereunder illustrates this point :—

Cocksfoot.	Pre-treatment.	Per cent. leaf in aggregate produce of 8 cuts taken in 1922.
Indigenous	cut 7 times in 1921.	80
Non-indigenous		78
Indigenous	cut 17 times in 1921.	88
Non-indigenous		80

It follows therefore that the effects of pre-treatment on the leaf to stem ratio in relation to strain are also similar in kind to the effects which show themselves during the year of treatment.

Very complete data are available in the case of Cocksfoot (B.60; pre-treatments in 1922) for comparing the effects on different nationalities and strains. The results are given in detail in Table XXIII. when pasture cuts have followed the pre-treatments, and in Table XXIV. when hay and aftermath cuts have followed the pre-treatments. In both tables vertical comparisons (= comparisons between the different strains and nationalities) with indigenous "tussocks" at 100 are shown in square brackets, and horizontal comparisons (=comparisons between the different pre-treatments for each strain or nationality as such) with the most lenient pre-treatment at 100 are shown in round brackets.

In the first place it is to be noted that the results from drills are of a precisely similar character to those recorded from single plants. Comparison of the ratios (in round brackets) between the results presented in terms of pasture cuts (Table XXIII.) with those presented in terms of hay and aftermath (Table XXIV.) show on the average of all the strains and nationalities that, if anything, both the drastic and intermediate pre-treatments have exhibited the greatest reduction when estimated in terms of hay *cum* aftermath. It is therefore evident that the period of unchecked recuperation allowed during the second growing season up to the date of hay cutting has been totally insufficient to permit of any considerable differential recovery and levelling up on the part of more drastically pre-treated drills.

It will be seen, moreover, by reference to Table XXIII. in the case of all strains and nationalities subjected to a system of pasture cuts in the second year that there was a more marked difference between the severe and intermediate pre-treatments compared to the lenient pre-treatments in the cuts taken up to and including May 24th, than in the sum of the eight cuts for the whole season, thus suggesting that there was probably some differential recovery in the later

* B.108, I., II. and III.

TABLE XXIV.—*To show the effect of various systems of cutting adopted in the first harvest year* (1922) *on the weight of produce developed in the second harvest year* (1923). *The data obtained in the second harvest year were from hay and aftermath cuts. Vertical and horizontal comparisons as in Table* XXIII.

Green weights in ozs. per row of 20ft. Cocksfoot B. 60.

Nationality and strain.	Pre-treatments in 1922.		
	Lenient: hay and aftermath (2 cuts)	Intermediate: monthly pasture cuts (10 cuts).	Drastic fortnightly pasture cuts (20 cuts).
	Sum of hay and aftermath 1923.	Sum of hay and aftermath 1923.	Sum of hay and aftermath 1923.
Indigenous tussocks	350 [100] (100)	273.0 [100] (78)	147.2 [100] (42)
,, dense pasture ..	306 [87] (100)	203.6 [74] (66)	137.4 [94] (44)
,, open	270 [77] (100)	193.4 [70] (71)	113.2 [76] (42)
Danish *cum* U.S.A.	296 [84] (100)	201.8 [73] (67)	103.4 [70] (34)
French	230 [66] (100)	176.4 [64] (76)	84.0 [57] (36)

stages of the growing season, and also emphasising the striking influences of drastic pre-treatments on the herbage offering early in the spring.

Both sets of data show that in many respects indigenous open-pasture behaved in a manner very similar to Danish *cum* U.S.A., and indicate that indigenous dense-pasture and tussocks, judged by both aggregate yields and ratios of lenient to the more drastic treatments, have resisted severe pre-treatments far better than Danish *cum* U.S.A., or than French ; Danish *cum* U.S.A., however, equalling dense-pasture both actually and relatively when judged in terms of hay *cum* aftermath (see Table XXIV.), following a pre-treatment of ten cuts. It is of particular interest to note that under the severest pre-treatment (20 cuts) dense-pasture outyielded tussocks on the sum of eight cuts in the second year, and relative to its own yield under the lenient pre-treatment was much the most resistant of all the strains. Judged in terms of hay *cum* aftermath it was still, relative to its own behaviour under lenient treatment, the most resistant, but was outyielded by tussocks.

The relation of the several strains and nationalities to each other under the various pre-treatments at the cutting dates early in the year bring out important economic differences (see Table XXIII).

When pre-cut twenty times, dense-pasture and tussocks, both absolutely and relatively showed to better advantage than Danish *cum* U.S.A., on the basis of the sum of the cuts March 10th and 29th in the second year, while by

FIGURE XII.—*To show the yield from each of seven monthly pasture cuts in the case of four nationalities and strains of Cocksfoot in* 1923 *when the rows had been cut monthly ten times in the previous year* (1922). *The yields on March* 10*th representing growth from the previous November are also shown.*

Yields in grams (green fodder) per row of 10ft. B. 60. 1923.

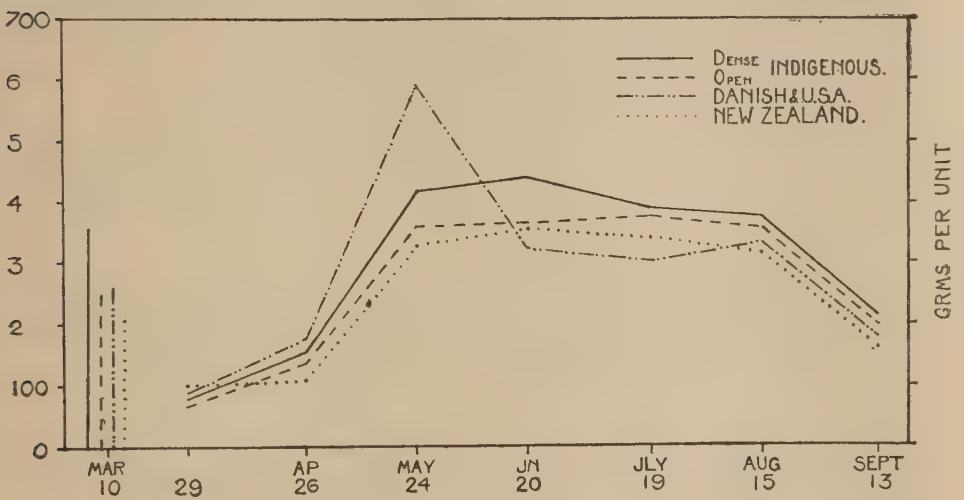
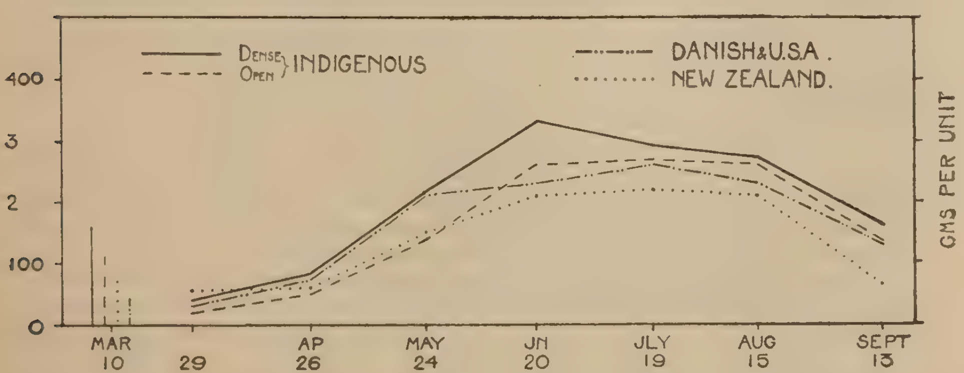


FIGURE XIII.—*To show the yield from each of seven monthly pasture cuts in the case of four nationalities and strains of Cocksfoot in* 1923 *when the rows had been cut fortnightly twenty times in the previous year* (1922). *The yields on March* 10*th representing growth from the previous November are also shown.*

Yields in grams (green fodder) per row of 10ft. B. 60. 1923.



May 24th the naturally quicker growing and earlier Danish *cum* U.S.A. (despite pre-treatment) have outyielded dense-pasture, which latter, however., relative to lenient pre-treatment had still maintained a slightly better ratio. Tussocks at this date still outyielded Danish *cum* U.S.A.

When pre-cut ten times dense-pasture still maintained a better ratio than Danish *cum* U.S.A. on the sum of the cuts March 10th and 29th, although considerably outyielded by the latter. Tussocks again outyielded both dense-pasture and Danish *cum* U.S.A., and also maintained the best ratio. By May 24th, under but ten pre-cuts, the earlier and quicker growth of Danish *cum* U.S.A., was able to influence the yield and thus these strains showed to considerably better advantage than dense-pasture or tussocks at this date.

When pre-cut only twice, Danish *cum* U.S.A. gave the heaviest yields at each of the early dates, viz., March 10th, 29th, and May 24th. It would thus appear that the superiority of Danish *cum* U.S.A. over the indigenous strains when growth becomes active in the spring may be entirely counterbalanced by sufficiently severe pre-treatment.

Reference to the graphs in Figure III. (pre-treatment—cut twice, see p. 29) ; Figure XII. (pre-treatment—cut ten times), and Figure XIII. (pre-treatment —cut twenty times), in which dense-pasture and tussocks have been averaged under "dense-indigenous" demonstrates the essential effect of pre-treatments and the relation of the nationalities and strains to such treatments. *Pre-cut but twice* gives a normal growth curve, with well marked primary and secondary peaks—Danish *cum* U.S.A. giving the highest yields early in the season and up to and including the hay period. *Pre-cut ten times* shows a somewhat flatter curve—particularly so in the case of indigenous and New Zealand strains, Danish *cum* U.S.A., however, show a well marked primary peak with good early and poor late productivity. The dense-indigenous are superior to the open-indigenous at all points, and decidedly superior to Danish *cum* U.S.A. at all dates after the middle of June. *Pre-cut twenty times* gives a humped rather than a peaked curve, with dense indigenous superior to all other strains and nationalities at all dates (except for the negligible superiority of New Zealand on March 29th).

It is to be noted that qualitatively New Zealand, as was to be expected, behaved like indigenous rather than Danish *cum* U.S.A., but quantitatively both under a ten and twenty pre-cut system it has fallen far short of indigenous.*

The effects of pre-treatment on Tall Oat Grass and Timothy are shown in Table XXV.—the results given are not nearly as reliable as in the case of the foregoing figures for Cocksfoot, because, as previously explained, the trials involved (B.76 and 77) did not give rise to satisfactorily established drills.†

The results, however, are in precisely the same direction as those for Cocksfoot, and afford confirmatory evidence of the ill-effects of severe pre-treatments. The very poor yields of Tall Oat Grass in March (when this grass is usually of high relative productivity) after severe pre-treatments, should be noted as a point of considerable practical significance.

The accumulative effect of pre-treatments continued over three harvest years is shown by reference to Table XXVI. for Cocksfoot. It will be seen that indigenous agg. both relative to its own yielding capacity under lenient pre-

* Only one lot of New Zealand Cocksfoot was included in the trial, so the evidence cannot be taken as of great significance, or as a definite indication that average New Zealand suffers more than average indigenous from severe pre-treatment.

† See p. 8.

TABLE XXV.—*To show the effect of various systems of cutting adopted in the first harvest year* (1922) *on the weight of produce developed in the second harvest year* (1923). *Data obtained in second harvest year from a system of* 8 *pasture cuts and from hay cum aftermath.*

Green weights in ozs. per row of 20ft. Timothy, B. 76, and Tall Oat Grass, B. 77.

Pre-treatments in the first harvest year 1922.	Yields obtained in second harvest year, 1923.					
	Sum of two pasture cuts, March 14th and 29th.		Sum of eight pasture cuts.		Sum of hay and aftermath.	
	Tall Oat.	Timothy.	Tall Oat.	Timothy.	Tall Oat.	Timothy.
Lenient: Cut twice, hay and aftermath ..	22.6	19.3	115.0	119.0	128.0	120.0
Intermediate: Ten pasture cuts	7.7	14.9	73.6	102.8	68.0	99.0
Drastic: Twenty pasture cuts	5.6	10.0	51.6	73.5	56.0	64.0

TABLE XXVI.—*To compare the effect of severe systems of cutting adopted in the first* (1920), *second* (1921), *and third* (1922) *harvest years, with lenient systems adopted in the same harvest years on the yield of hay developed in the fourth harvest year* (1923). *The figures in square brackets are vertical comparisons and those in round brackets horizontal comparisons, as in previous tables.*

Oz. green weight per drill of 52in. Cocksfoot, B. 1.

Nationality.	Pre-treatments.	
	Cut once in seeding year and twice in each of the first three harvest years.	Cut twice in seeding year (1919) 7 times in 1st harvest year (1920), 13 times in 2nd harvest year (1921), and 8 times in 3rd harvest year (1922).
	Yield of hay in fourth harvest year, 1923.	Yield of hay in fourth harvest year, 1923.
Indigenous agg. ..	44.0 [100] (100)	33.0 [100] (75)
Danish *cum* U.S.A. ..	38.0 [83] (100)	16.6 [50] (43)
French	21.0 [47] (100)	10.7 [32] (51)
Average of all nationalities	34.0 [—] (100)	20.1 [—] (59)

treatment and in absolute yield, has maintained productivity under severe pre-treatment (continued for three years) altogether better than Danish *cum* U.S.A., or than French. French, although yielding much less than Danish *cum* U.S.A. under severe pre-treatment has maintained a better ratio relative to its own yielding capacity under lenient pre-treatment.

It must be remembered that except in the case of Sweet Vernal Grass all the data here considered relative to pre-treatment have been collected on the larger grasses, all of which (even Timothy) are capable of considerable productivity early in the spring. For these larger grasses and Sweet Vernal Grass it appears, however, to be evident that severe systems of cutting adopted in one year leave a legacy of ill effect into the following year. The results are qualitatively similar in both the year of treatment and in the subsequent year, and are revealed in terms of reduced yield; increased contribution of leaf to total bulk, in a flattening or "humping" of the seasonal growth curve (compare Figures XII., and XIII. with Figure XI.), and in reduced root and tiller development.

(2) EFFECT DURING THE SECOND SEASON FOLLOWING THE TREATMENT. The figures in Table XXVII. afford material demonstrating the fact that the ill effects of severe pre-treatment, at all events in the case of Cocksfoot, may continue operative at least into the spring of the second season following its application. Unfortunately only single plant data are at present available, and only in the case of pre-treatments instituted in dry 1921.

First to consider the results given by the "A" section of the table, that is to say where (1) drastic, (2) intermediate, and (3) lenient treatments,* adopted in the first harvest year have been alike followed up in the second harvest year by relatively drastic treatment.

We find that the degree of rigour super-imposed upon the plants in their first harvest year has shown itself in a perfect gradation of yields obtained early in the spring of the third harvest year. It is to be particularly noted, moreover, that the yield given by the plants subjected to least drastic pre-treatment in the first harvest year has actually been twice as great as that achieved by those plants most drastically cut during the first harvest year.

It will be seen that the difference in root weight between the most and least severe pre-treatments shows but slightly in favour of the least drastic—evidently the root development had been much more levelled up by the uniform and rather drastic treatment (itself severe enough to depress root development) adopted in the second harvest year than had the yields. This suggests that had it been possible to continue cuts all through the third harvest year the aggregate yields would have been levelled up to a considerable extent by the end of the season.

Turning to the "B" section of the table, where (1) drastic, (2) intermediate, and (3) lenient treatments adopted in the first harvest year have been followed in the second harvest year by very lenient treatment, we find not only that recuperation has been much more complete, but that the effect of the degree of

* 17 cuts = drastic; 10 and 7 cuts = intermediate; 3 cuts = lenient. It has been shown that the difference between 10 and 7 cuts is not considerable, consequently, and having regard to the fewness of the plants treated, no particular significance is to be attached to the fact that in the "B" section of the table the plants pre-cut 10 times have shown to better advantage than those pre-cut 7 times.

TABLE XXVII.—*Data on single plants of Cocksfoot. To show the effect of various systems of cutting performed in the first harvest year, on the yield obtained early in the spring of the third harvest year.*

Weights per single plant. B. 108 I.

Pre-treatments.		Data obtained on April 16th in the third harvest year (1923).				
In the 1st harvest year (1921).	In the 2nd harvest year (1922).	Total dry wt. in grs. of stem and leaf together.	Relative with the yield ex plants cut 17 times in 1921 placed at 100.	Per cent. of leaf in total dry weight.	Dry weight of roots on plants dug up at date of cutting.	Number of plants averaged.
A.—Pre-treatments in the first harvest year (1921) followed in the second harvest year (1922) by relatively rigorous treatment.						
Cut 17 times.	Cut 8 times.	7.1	100	82.0	5.7	8
,, 10 ,,	,, 8 ,,	12.3	173	79.0	6.5	5
,, 7 ,,	,, 8 ,,	14.3	201	79.0	8.9	16
,, 3 ,,	,, 8 ,,	15.8	222	80.5	8.1	5
B.—Pre-treatments in the first harvest year (1921) followed in the second harvest year (1922) by relatively lenient treatment.						
Cut 17 times.	Cut twice	41.5	100	71.0	27.2	5
,, 10 ,,	,, ,,	52.5	126	74.0	36.5	3
,, 7 ,,	,, ,,	41.8	100	76.0	31.5	6
,, 3 ,,	,, ,,	67.6	162	66.0	40.2	2

rigour super-imposed in the first harvest year is not nearly so well marked. The figures would suggest that the earlier difference between the plants pre-cut seven and ten times respectively in the first harvest year has been smoothed out, but that even after ideal conditions for recuperation during the second harvest year, the plants least drastically treated in the first harvest year still have a decided advantage over those most drastically treated (pre-cut seventeen times), even by the spring of the third harvest year. It is interesting to note that when root development has not been hampered in the second harvest year, the most drastically pre-treated plants still show to a decided disadvantage in this respect in comparison with the least drastically pre-treated.

VIII.—Comparisons between different species of Grasses and between Indigenous and Non-Indigenous strains of the same species.

It may serve a useful purpose, even at the risk of slight reiteration, to consider in a little more detail the behaviour of individual species in relation to the phenomena dealt with in the previous sections.

It is of interest at the outset to compare the general behaviour of indigenous strains with non-indigenous without regard to species.

Table XXVIII. affords material for such a comparison, on a percentage basis with the yields from indigenous expressed at 100 in each case. It must be pointed out, as previously explained, that 1921 was more favourable to indigenous than to non-indigenous strains, and also that the general conditions of experiment B.93 (making for poor establishment) were probably also more favourable to indigenous. On the other hand the yields recorded appertain only to the first and second harvest years, and to that extent, as previously suggested, are probably favourable to the non-indigenous strains. These particular results quantitatively considered are in consequence only necessarily to be taken as an indication of the greater suitability of indigenous strains for exacting conditions—a sufficiently important recommendation. It is, however, the qualitative aspect of the figures given in the table that call for emphasis in the present connection.

The more rapid and early growth of the non-indigenous than of the indigenous strains is abundantly shown, firstly by the greater yield in the autumn of sowing (see "B" section), and secondly by the much heavier yields obtained early in the spring of 1922 and 1923 (see "A" section)—the early advantage was, however, largely counter-balanced in 1921 by the greater resistance of the indigenous strains to the effect of the drought. It will be noted also that in 1921 the non-indigenous strains compared most favourably to the indigenous on the basis of hay yield—while in 1923 (and on the average of 1922 plus 1923) they showed to the best relative advantage judged by the sum of a system of pasture cuts. This again indicates the general ability of non-indigenous strains to "pick up" and grow more quickly than indigenous—but also shows, as before explained, that in order to yield heavily under pasture cuts the plants must be capable of a high degree of resistance to the severity of the conditions super-imposed, the latter being the chief factor influencing yield under pasture conditions during 1921. The number of tillers per unit of area as between indigenous and non-indigenous (as 100 to 57) after two years rather drastic treatment (see first column of "A" section) is in keeping with the results previously discussed, and affords further evidence of the greater powers of resistance and generally greater potential perenniality of indigenous grasses con-

TABLE XXVIII.—*To compare indigenous with non-indigenous strains of grasses (average results including a number of species) Results for* 1922 *and* 1923 *from B.* 93—*in "A" section of Table, and for* 1921 *from B.* 14, *B.* 21, *B.* 29 *and B.* 36 *in "B" section of Table.*

Results expressed relatively with yields from indigenous as 100 in all cases.

Strain.	Actual No. of tillers per 6in. × 6in. at end of 1923	Cuts representing growth from middle of March to middle of May.		Cuts representing growth in October, 1922	Sum of pasture cuts.			Hay.			Aftermath.			Sum of hay aftermath and pasture.		
		1922	1923		1922	1923	1922 and 1923	1922	1923	1922 and 1923	1922	1923	1922 and 1923	1922	1923	1922 and 1923
		"A" Average of Cocksfoot, Perennial Rye Grass, Tall Oat, Timothy, Tall Fescue, Meadow Fescue, Golden Oat, Red Fescue, Sweet Vernal Grass and Meadow Foxtail.*														
Indigenous	51	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Non-indigenous ..	29	200	135	77	84	99	91	88	73	81	96	75	85	88	84	86

	Autumn growth in seeding year, 1920	Growth in Mar. and April, 1921	Sum of pasture cuts, 1921	Hay, 1921	Aftermath, 1921	Sum of hay, aftermath and pasture, 1921
	"B" Average of Cocksfoot, Perennial Rye Grass, Tall Oat Grass and Timothy.†					
Indigenous	100	100	100	100	100	100
Non-Indigenous ..	125	104	79	100	72	85

* Actual yields (except for early spring and autumn) cuts given in Table XXIX.

† Actual yields in Table V of previous bulletin, see (32), p. 20.

sidered in the aggregate. It should be remarked that whereas under normal conditions (in the first harvest year and possibly later also if severe treatments are not adopted), the non-indigenous will tend to yield most heavily early in the spring, the indigenous have the advantage during October (in first and subsequent harvest years). It is, however, in respect of aftermath that the indigenous strains most consistently show their superiority over the non-indigenous.

The comparative behaviour of the different species can be examined by reference to the results given in detail from the tiller bed trial (B.93) in Table XXIX., and summarised on a percentage basis in Table XXX. It is to be remembered that the tiller beds had not developed into the counter parts of reasonably dense swards, and the yields as such were decidedly light—the results are therefore chiefly of interest as affording a comparison between the species under conditions (no matter how super-imposed) far from favourable and because pasture cuts. as well as merely hay and aftermath have contributed to the gross yields. The results for 1922 may be taken as comparatively quite reliable, while those for 1923 were upset by the poor yields of Cocksfoot in the hay, and since the yields generally of the larger grasses were poor in the latter year (see Table XXIX.), the smaller grasses took a relatively higher position (and probably exceptionally high) in 1923 than in 1922—a state of affairs which would doubtless be realised under poor conditions generally. Detailed comparisons are in consequence only made for 1922 (see Table XXX.), gross yield comparisons are, however, also made for 1923, and for the sum of 1922 and 1923.

It will be seen that the grasses fall into three yielding classes. The highest yielding being Cocksfoot, Tall Oat Grass, Tall and Meadow Fescue, Meadow Foxtail, Timothy and Perennial Rye Grass ; Golden Oat Grass, Sweet Vernal Grass and Poa serotina take an intermediate position ; Red Fescue, Crested Dog's Tail, and probably Rough and Smooth Stalked Meadow Grasses* being perhaps of the lowest aggregate productivity. The results agree fairly well with those given by Hunter (33), though observations would suggest that Rough Stalked Meadow Grass stands rather too high in his scale. Hunter's scale shows a greater difference between Cocksfoot, Tall Oat Grass and Tall Fescue on the one hand, compared on the other with Timothy, Perennial Rye Grass, Meadow Foxtail and Meadow Fescue.

The poor aftermathing ability of Timothy and Perennial Rye Grass are emphasised by the figures, equally interesting are the high aftermath positions taken by the two early grasses Meadow Foxtail and Sweet Vernal Grass,† doubtless in large measure due to the longer period available for the production of after-grass in consequence of the relatively early hay crop.

It is of interest to note that whereas most species have fallen in gross productivity in 1923 (see Table XXIX.), Meadow Foxtail (indigenous). Red Fescue, Sweet Vernal Grass and Crested Dog's Tail have advanced very appreciably. These are grasses which establish themselves rather slowly on new swards. Trials conducted in Sweden by (1) Osvald (20), showed Meadow Foxtail to yield fairly well in the first year and then to drop, only recording maxi-

* Based on observation ; owing to weediness the full series of plots were not included in the cutting scheme.

† The relatively high aftermathing ability of Meadow Foxtail was also shown in drill trials (B.62), the ratio aftermath to hay was 100 to 93 in 1922 and 100 to 114 in 1921. Sinclair (25) refers to the excellence of the aftermath of Sweet Vernal Grass, and it would seem probable that these two early grasses are relative to other species more productive in the late summer and autumn than in the early spring.

TABLE XXIX.—*To show the yields of hay, aftermath and pasture for a number of species and nationalities of grasses for 1922 and 1923. In oz. green weight per one yard square. The number of tillers per unit of area (6in. by 6-in.) at the end of the second harvest year (1923) is also shown.*

Data on rather poor yielding "Tiller Beds." B. 93.

Species and nationality.	Sum of pasture cuts.			Hay.			Aftermath.			Sum of hay, aftermath and pasture.			Number of tillers per 6in. × 6in. in Nov., 1923
	1922	1923	1922 and 1923	1922	1923	1922 and 1923	1922	1923	1922 and 1923	1922	1923	1922 and 1923	
Cocksfoot, Indigenous	57	42	99	40	25	65	22	13	35	119	80	199	30.3
Danish *cum* U.S.A. ..	50	47	97	46	20	66	19	10	29	115	77	192	13.0
Per. Rye Grass, Indigenous ..	51	33	84	42	39	81	11	14	25	104	86	190	87.0
Danish .. Ayrshire .. Swedish .. }	51	35	86	36	27	63	7	12	19	94	74	168	57.0
Tall Oat Grass, Indigenous ..	41	33	74	41	35	76	19	13	32	101	81	182	41.0
French	39	46	85	37	27	64	19	14	33	95	87	182	19.0
Timothy, Indigenous	45	25	70	41	46	87	5	10	15	91	81	172	43.0
U.S.A. & Ayrshire ..	39	30	69	44	26	70	16	11	27	99	67	166	18.0
Tall Fescue, Indigenous	45	42	87	36	35	71	22	17	39	103	94	197	17.0
Dutch	31	36	67	20	29	49	14	13	27	65	78	143	18.0
New Zealand	42	34	76	36	33	69	24	12	36	102	79	181	18.0
Meadow Fescue, Indigenous ..	43	47	90	33	31	64	18	19	37	94	97	191	17.0
Danish & U.S.A.	34	37	71	29	17	46	19	12	31	82	66	148	10.0
Meadow Foxtail, Indigenous ..	44	45	89	32	24	56	24	38	62	100	107	207	28.0
Danish	29	37	66	22	11	33	17	20	37	68	68	136	20.0
Golden Oat, Indigenous	34	34	68	34	35	69	16	18	34	84	87	171	68.0
French	27	25	52	15	22	37	9	10	19	51	57	108	34.0
Fine Fescues, Indigenous	29	25	54	13	27	40	9	14	23	51	66	117	—
Chewings	24	34	58	15	27	42	13	17	30	52	78	130	—
Sweet Vernal Grass, Indigenous ..	31	35	66	14	23	37	16	26	42	61	84	145	56
German ..	23	32	55	16	18	34	15	20	35	54	70	124	27
Crested Dog's Tail, Ind. & Irish ..	25	28	53	14	30	44	7	12	19	46	70	116	36
Poa Serotina, Commercial	38	27	65	30	17	47	16	14	30	84	58	142	22

TABLE XXX.—*To compare the yields of the different species of grasses (taking the average of indigenous and non-indigenous strains) when estimated in terms of hay, aftermath and pasture respectively for* 1922. *Also to compare the yields, when estimated in terms of the sum of hay, aftermath and pasture respectively for* 1922 *and* 1923, *and when estimated in terms of the gross yield for* 1922 *plus* 1923. *The yield for Cocksfoot expressed as* 100 *in each case. The average flowering date and the height in cm. when cut for hay are also shown for* 1922. *For comparison the relative yielding power of the species growing to luxuriance on soils that suit them is shown in the last column.*

Summary of Table XXIX. B. 93.

Species.	1922. Pasture.	1922. Hay.	1922. Aftermath	1922. Ht. in cm. at hay.	1922. Flowering date.*	Sum of pasture, hay and aftermath. 1922	Sum of pasture, hay and aftermath. 1923†	Sum of pasture, hay and aftermath. 1922 & 1923	Standard ratio of yields‡
Cocksfoot	100	100	100	103	June 7—16	100	100	100	100
Tall Oat Grass	75	91	92	112	,, 16—29	84	107	93	100
Per. Rye Grass	95	91	44	61	,, 15	85	102	92	70
Timothy	78	98	51	90	July 10—24	81	94	86	75
Tall Fescue	73	71	97	114	June 21—29	77	106	89	100
Meadow Foxtail	72	72	90	89	,, 21—29	75	104	87	70
Meadow Foxtail	68	63	100	79	May 25	72	111	88	70
Poa Serotina	71	70	78	70	June 15	72	74	73	—
Golden Oat	57	57	61	75	,, 21	58	92	71	55
Sweet Vernal	50	35	75	53	May 7-June 7	49	98	69	50
Red Fescue	49	32	53	56	June 16	44	94	63	40—50
Crested Dog's Tail	47	32	34	51	,, 21	39	89	59	45

* In every case the latest flowering date was indigenous.
† The figures for 1923 were upset by exceptionally poor hay yields from Cocksfoot.
‡ See (33).

mum productivity in the seventh year, by (2) Witte and Nystrom (30), indicated that both Meadow Foxtail and *Poa pratensis* are grasses which increase in yield each year. and by (3) Rhodin (23), who included Meadow Foxtail in a mixture at the rate of over 9 lb. per acre, and proved that this grass did not come into maximum bearing until the fourth year.

Sinclair (25) shows that in pure cultures Meadow Foxtail only produced maximum bulk in about the fourth year ; seed production rows at Aberystwyth have shown a considerable increase in the size of the plants over a period of three years, while field trials now in progress (at Aberystwyth) show Chewing's Fescue, even in a simple three species mixture, altogether more productive in the second than in the first harvest year,* the behaviour of single plants grown for breeding purposes also suggesting a gradual increase of productivity over at least a three to four year period.

This section may usefully be concluded by referring in some detail to the yielding capacity of different strains and nationalities of Cocksfoot, a species which has received more attention (relative to yield trials) than other grasses.

It will have been seen from Table II. (p. 20), giving particulars as to hay and aftermath, and Tables XXIII. (p. 66) and XXIV. (p. 68), giving particulars of pre-treatments, that indigenous tussocks have on the average outyielded all other strains and nationalities by a wide margin, and that even indigenous agg. has shown to great relative advantage in the fourth harvest year (B.1). Indigenous tussocks have shown to particular advantage in the third harvest year (B.14, no trial with this strain as such yet being in the fourth harvest year), and in all trials (see particularly B.60) this strain has been remarkable for exceptionally high yields of aftermath.

The figures in Table XXXI., showing the gross yields from the sum of hay, aftermath and pasture cuts for the three harvest years 1921—23 (B.14), and for the two harvest years (1922—23 (B.60), constitute very reliable data for comparing the productivity of the different nationalities and strains of Cocksfoot. The results are qualitatively in absolute agreement and indicate the outstanding relative productivity of tussocks ; indigenous dense-pasture and open-pasture both being unmistakably superior to Danish *cum* U.S.A., which latter nationality is as strikingly superior to French. B.60 shows New Zealand on a par with dense pasture and superior to Danish *cum* U.S.A. Up to the present an insufficient number of lots of New Zealand have been under prolonged trial, but it is evident that much of the seed coming from New Zealand gives rise to plants almost indistinguishable from some of the indigenous strains. Trials with single plants B.56 (II.) also bear evidence of the high yielding power of indigenous tussock, which even in the first harvest year has averaged yields 6 per cent. greater than Danish *cum* U.S.A.

It must not be presumed that indigenous seed (even "tussocks") sown in broadcast plots or included in seed mixtures will necessarily out-yield Danish *cum* U.S.A., even in the second and subsequent harvest years by the wide margins which the above results (sown drills and rows of closely planted propagants) have shown. The seedlings appear to take longer to establish themselves from indigenous strains than from Danish *cum* U.S.A., and consequently it may not always be possible to obtain such good "takes" from seed of the former as of the latter strains—while early competition with more vigorous

* It is to be observed that these results were most striking in hay *cum* aftermath yields, which were not to any appreciable extent influenced by weeds.

TABLE XXXI.—*To compare the gross yield from different nationalities and strains of Cocksfoot, respectively, for the two harvest years* 1922-23 (*B*.60), *and for the three harvest years* 1921-23 (*B*.14).

Green weights.

Nationality and strain.	Sum of hay, aftermath and pasture cuts.			
	Sum of two harvest years, 1922-23.		Sum of three harvest years 1921-23.	
	In oz. per 20ft.	Relative.	In oz. per 52in.	Relative.
Indigenous tussocks ..	1337	100	301	100
Dense pasture	1021	76	263	87
Open pasture	1012	75	251	83
New Zealand	1076	80	—	—
Danish *cum* U.S.A. ..	925	69	229	76
French	793	59	165	55

species may be expected to interfere more with the establishment of the slower growing seedlings.*

The immediate interest in the comparisons as made above of course turns on the evidence that they afford of the wide difference in yielding capacity as between different strains of the same species, and therefore of the undoubted scope that exists for the improvement of herbage grasses.

IX.—Summary and General Conclusions.

The results brought out by the trials considered in this article and supplemented by references to current literature on the subjects under review, may be briefly summarized as follows :—

(1) Under normal conditions most of the grass species if grown in pure cultures will probably yield their heaviest crops in the first harvest year—definite exceptions to this rule appear, however, to be Meadow Foxtail of the

* The above points are now under detailed study at the Station, but they present numerous difficulties, the more so because early growth and establishment appear to be much affected by the quality of the seed sown—and it is difficult to harvest at Aberystwyth seed of indigenous grasses of as high germinating capacity and of the same high quality as that now put on the market from Denmark and other exporting countries.

larger grasses and Red Fescue. Crested Dog's Tail and Smooth Stalked Meadow Grass of the smaller grasses, while it is also more than likely that indigenous strains of some of the larger grasses, such as Cocksfoot, yield rather more heavily in later harvest years than in the first.

(2) The relation of the yield in the first harvest year to subsequent harvest years is influenced largely by the weather conditions in the first and second harvest years—if the weather is then unfavourable the heaviest yields for most species and strains will be obtained in the third or fourth harvest years.

(3) The yield of hay in any particular year is affected to a very considerable extent by the meteorological conditions—especially amount of rain falling, modified in its absolute effects by soil temperature, from the date when growth fairly starts in the spring until the date of cutting. Since available soil moisture is also influenced by the amount of sunshine—the average intensity of sunshine will exercise a marked controlling influence particularly when rainfall is below the average.

(4) The yield of aftermath in any particular year is affected largely by the meteorological conditions obtaining during a period from about a week before cutting the hay until cutting the aftermath, but would appear also to be appreciably influenced by the size of the hay crop—very heavy crops of hay and aftermath in one and the same season may be regarded as exceptional. It cannot at present be said whether this is due to a definite relationship between aftermath yield and hay yield, or to it being exceedingly unlikely that ideal weather conditions for both hay and aftermath will obtain in one and the same year.

(5) Both the yield of hay and aftermath are influenced to a very considerable extent by the date of "putting up" to hay. "Putting up" to hay later than the end of February or possibly than early in March is likely to show considerably reduced yields over "putting up" earlier. The date of cutting the hay reacts on both the yield of hay and the aftermath; late cutting, although compatible with heavy yields of hay, occasions reduced aftermaths.

(6) The seasonal productivity of pastures (as illustrated by a rather lenient system of pasture cuts) is affected as much or more by the plants functional periodicity as by meteorological conditions. Maximum growth will usually occur in May and June, when inflorescences tend to be developed, a well marked secondary peak usually showing itself in August or September, when inflorescences are sometimes again developed to a slight extent. The growth in any particular incremental period is affected more by the meteorological conditions in the immediately preceding period or periods than by those obtaining in the current period.

(7) The heaviest gross yields are to be obtained when the first cut is taken as hay at flowering period, and when this cut is followed up by two aftermath cuts. The amount of extra yield obtainable from a single or from two aftermath cuts in addition to hay will depend upon the season. When the spring has been dry, or cold and fairly dry, and the later summer and autumn favourable to growth—the gross produce may be doubled or more than doubled by adding two aftermath cuts to the hay cut. When on the other hand the conditions have been favourable for hay production, a second aftermath cut will not add materially to the gross produce, while even a single aftermath added to the hay crop may not in extreme cases add as much as 10 per cent. to the gross yield.

(8) (*a*) A system of cuts starting with the hay crop will usually produce a greater gross bulk of produce than a system of the same number of cuts starting before hay period ; (*b*) a system consisting of a hay cut and one aftermath will usually outyield a system of only four cuts, when the first is taken before hay ; (*c*) in proportion as more than four pasture cuts (cuts starting before hay) are taken, so will the aggregate yield from the sum of the cuts decrease. The greatest reduction appears to manifest itself when the number of cuts exceeds about ten per growing season.

(9) In general, non-indigenous strains show to the best advantage relative to indigenous when judged by a system of pasture cuts varying from about five to seven per growing season—and to the least advantage when judged by a drastic system of pasture cuts (13—17). Indigenous take the highest relative position in aftermath, hay and under a drastic system of pasture cuts. It is thought that the capacity to be productive under pasture cuts turns on a plant's ability (*a*) to " pick up " and grow quickly after each cut, and (*b*) to withstand the adverse physiological conditions occasioned by repeated cutting. Under a lenient system of cutting the greater persistency of the indigenous strains is partially set off by the greater capacity for " picking up " of the non-indigenous—under a drastic system persistency becomes the dominating factor influencing yield.

(10) The disparity between the yields from " few cut " and " many cut " systems becomes even more exaggerated in proportion as the conditions are unfavourable during the growing season due, *e.g.*, to drought.

(11) The date at which a system of pasture cuts is initiated has a profound influence on the gross yield obtainable from such a system. A system started when the plants have attained to full heading will outyield a system started prior to such a date ; and date for date throughout the remainder of the season the highest yield will tend to be with the system started at heading period.

(12) If instead of taking an aftermath cut subsequent to the hay cut, a number of pasture (= after) cuts are taken, and at the same dates as pasture cuts representing a pasture system started in about April—date for date the after-cuts will tend to outyield the pasture cuts, and in the aggregate over the date range common to both will do so by a considerable margin.

(13) Cutting to a level of 2-in. above the ground instead of to ground level made for an increase in the gross produce from a system of seven pasture cuts.

(14) The percentage of leaf in total produce is at its lowest in the hay and at its highest in the aftermath and under a system of pasture cuts. In proportion as the number of pasture cuts is increased so does the percentage leaf in the aggregate produce from the system tend to increase. The amount of leaf as such developed in a hay *cum* aftermath crop tends, however, to be more than that developed under a system of pasture cuts, while the gross yield of leaf is greater from a system of relatively few than from a system of many pasture cuts.

Under a fairly lenient system of pasture cuts (say about seven per season) stem will outyield leaf during the period of maximum growth for a few weeks in May and June, but subsequently and until the end of the season leaf will outyield stem, and generally by a wide margin. Leaf will usually develop a considerable secondary peak (sometimes higher than the primary peak) in August

or September—if stem shows such a secondary peak at all it will be but slight. Under a drastic system of cutting (ten to seventeen cuts per season) leaf will tend to outyield stem at all dates (even May and June) throughout the season—under a very drastic system (13—17 cuts) the disparity betwen stem and leaf is particularly well marked, the yield of the former being negligible for the closing periods. Under drastic systems of cutting indigenous strains tend to give rather higher percentages of leaf than non-indigenous.

(15) The percentage dry matter in total green fodder is at its highest in the hay—and is very similar in aftermath to what it is in the average of a number of pasture cuts taken throughout the season. The percentage dry matter in the aggregate produce of a number of pasture cuts is higher when the number of cuts is comparatively few than when the number is considerable. The percentage dry matter in green fodder, like gross yield, and the stem to leaf ratio, appears to be affected as much or more by the plants functional periodicity as by meteorological conditions. Judged by a lenient system of pasture cuts, the percentage is at its lowest when growth is most active (May and June)—thus when yields are high the ratio dry matter to total yield tends to be low. When growth is at a low ebb early and late in the season the ratio tends to be high—while in the dead season it may be further increased by the presence of burned (and dead) or partially burned (and partially dead) leaves.

There is considerable evidence for supposing that rainfall has an indirect rather than a direct influence on the ratio dry matter to total green produce. In so far as rainfall favours active growth it will favour a decreased ratio dry matter to total green fodder. Thus the ratio is presumably influenced as much or more by the rain falling some time before a cut is made as by that falling more or less contemporaneously (always assuming that the green weight of the produce of the cut represents a *dry green weight*).

(16) The root systems of grasses are very sensitive to cutting. In proportion as grasses are frequently cut (upwards of four times per season) provided the first cut is taken before heading stage, so is the root system developed by the end of the season greatly reduced—and the same is true of tiller development.

(17) The reduction in root and tiller development reveals itself in terms of diminished yield all through the subsequent season, and when the initial cutting system has been particularly drastic, into the spring of the second season (= third harvest year). The greatest reduction in yield shows itself when growth is starting early in the spring following the year of pre-treatment. Reduced yields are not only shown when estimated in terms of pasture cuts in the year following the pre-treatments, but to an equal extent when estimated in terms of the sum of hay and aftermath cuts.

(18) The effect of drastic pre-treatment is similar in its qualitative influence to the effect of repeated cutting revealed during the season of application. That is to say, it shows itself in terms of reduced yield; and in a flattened or humped seasonal growth curve; with the ratio leaf to stem in the aggregate produce higher than when the pre-treatment has been lenient.

(19) In the case of Cocksfoot it has been shown that indigenous strains—particularly dense-pasture—are most resistant to drastic pre-treatments, while both dense-pasture and tussocks have proved themselves considerably more resistant under drastic and intermediate treatments than Danish *cum* U.S.A.

Under drastic pre-treatment tussocks have given slightly higher yields even in May than Danish *cum* U.S.A., while under intermediate equally with lenient pre-treatment, Danish *cum* U.S.A. have shown to much the best absolute and relative advantage from the middle of March to the middle-end of May.

(20) Comparisons between different species and between indigenous and non-indigenous strains of grasses have shown (*a*) that the non-indigenous tend to give the heaviest yields early or comparatively early in the spring (this will not be the case when following drastic pre-treatment) and also in the autumn of the seeding year, (*b*) indigenous tend to give the heaviest yields in the later summer and autumn. (*c*) the indigenous tend to give a more leafy herbage than the non-indigenous, this is most striking in the case of the hay, (*d*) Cocksfoot, Sweet Vernal Grass and Tall Fescue appear to be particularly leafy grasses in hay, aftermath and pasture alike ; Tall Oat Grass (French), Crested Dog's Tail and Golden Oat Grass appear to be amongst the least leafy grasses. (*e*) at the end of a second harvest year after pasture cuts in both the first and second harvest years the number of tillers per unit of area tends to be far greater in the indigenous than non-indigenous, (*f*) the highest yielding grasses grown in pure cultures, having regard to hay, aftermath and pasture, and to results obtained over two harvest years—apparently are (of the species tested) Cocksfoot, Tall Oat Grass, Tall and Meadow Fescue, Timothy, Perennial Rye Grass and Meadow Foxtail ; those taking an intermediate position are Golden Oat Grass, Sweet Vernal Grass and Poa serotina ; while those of the least aggregate productivity are Red Fescue and Crested Dog's Tail, with probably the Rough and Smooth Stalked Meadow Grasses.

The above summary is, of course, conditional on the reservations made in an earlier section dealing with "material and methods," and only necessarily applies to the behaviour of the plants at Aberystwyth under the conditions stated, and under the treatments actually adopted.

The economic implications of the results as a whole are, however, of considerable importance and will be dealt with most conveniently in conjunction with the results of the chemical evidence in a short concluding article.

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The Nutritive Value of Grasses as shown by their Chemical Composition*

by

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Introduction.

When it is remembered, that in Wales two-thirds of the land—other than that given over to mountain and heath—is down to permanent grass, it will be readily realised, that one of the country's most important agricultural problems, is the improvement and care of its grassland.

As a result of some preliminary work undertaken during the season 1921 with repeated fortnightly cuttings of individual grasses, it was thought, that information of value might be obtained if the chemical composition of repeated cuttings from a number of these grass plots was ascertained. For, as far as we are aware, no attempt has been made in this country to estimate the grazing value of individual grasses as shown by their chemical composition.

This paper gives the results of the work carried out during seasons 1922 and 1923 with the following fifteen grasses, being representatives of the chief species and strains under investigation at the Station.

A commercial and indigenous variety of :—

Cocksfoot	U.S.A.
,,	Indigenous.
Perennial Rye Grass	Danish.
,, ,, ,,	Indigenous.
Timothy	U.S.A.
,,	Indigenous.
Tall Oat Grass	French.
,, ,, ,,	Indigenous.

and indigenous varieties of :—

Golden Oat Grass.
Crested Dog's Tail.
†Rough Stalked Meadow Grass.
Red Fescue.
Meadow Fescue.
Tall Fescue.
Meadow Foxtail.

* Being an extension of the results which were put before the A.E.A. in a paper read at Aberystwyth in June, 1923.

† From the beginning the Rough Stalked Meadow Grass plot was unsatisfactory, and in the second season it was discarded

The work entailed :—

(*a*) The analysis of cuts taken from the same square yard of each plot, at approximately monthly intervals.

(*b*) The analysis of the hay and aftermath from another similar area of each plot, and

(*c*) The analysis of stem and leaf separations of some of the above grasses grown on other plots.

The soil is a thin light loam containing 25 per cent. of stones ; it is formed from the Aberystwyth Grits—a sub-group of the Lower Silurian—which occupy large tracts of Cardiganshire and the adjacent counties. Compared with similar soils in the neighbourhood, the garden soil is better supplied with available phosphates, having 0.23 per cent. total phosphate and 0.014 available,* but, like the large majority of these soils, contains no carbonate of lime.

The experiment used for the purpose of the analysis was B.93, full particulars of which are given in the previous paper, single plots only of the species and strains selected being used.

The general meteorological conditions during the growing seasons 1922 and 1923 were :—

1922.

	March.	*April.*	*May.*	*June.*	*July.*	*Aug.*	*Sept.*
Rainfall in ins...	2.96	1.89	1.56	1.06	3.51	4.25	3.61
Average per day	0.16	0.14	0.14	0.06	0.19	0.24	0.22
No. of rainy days	18	13	11	17	18	17	16
Sunshine in hours	131	212	208	172	169	139	116
Average per day	6	7	7	7	6	5	5
Days without sun	4	1	3	7	6	4	8

1923.

	March.	*April.*	*May.*	*June.*	*July.*	*Aug.*	*Sept.*
Rainfall in ins...	1.25	2.44	3.64	1.17	4.51	3.53	4.70
Average per day	0.08	0.12	0.17	0.10	0.26	0.15	0.21
No. of rainy days	14	19	21	11	17	23	22
Sunshine in hours	95	148	196	145	136	140	134
Average per day	3.5	5.5	7	6	5.5	5.5	5.5
Days without sun	4	3	3	6	6	7	4

The total rainfall during the seven months March to September inclusive was 18.84 inches in 1922 and 21.24 in 1923, 60 per cent. in each year falling during the last three months. The driest month in both years was June, the wettest in 1922 being August, and in 1923 July. The greatest amount of sunshine occurred during April and May ; September in 1922 and March in 1923 having least sunshine.

The Management and Sampling of Plots.

Full particulars of the management of the plots (B.93) have been given in the previous paper,† and the only point to which attention should be drawn here is that the portion of the plot cut for pasture in 1922 was kept for hay in 1923 and *vice versa*.

* The relatively satisfactory position as to phosphates being entirely due to the heavy dressing of slag and superphosphate applied since the Gardens were taken over by the Station.

† See page 8.

All the grass cuttings, including the hay and aftermath, were weighed as soon as possible after cutting, the interval between the completion of cutting and weighing the produce being in no case longer than five minutes. From each cutting a representative sample was taken and weighed for chemical analysis. These samples were placed in bags and taken to the laboratory, where they were spread on trays to dry at ordinary room temperature, the final drying being completed in the water oven. Before analysis, each sample was reduced to as fine a state as possible, the dry grass being first cut with a pair of scissors into fine chaff, and this chaff reduced to a fine powder by passing it through a grinding mill.

In addition to the usual determinations carried out in the analysis of a food stuff, the true protein in the fine powder was estimated from the nitrogen precipitated by means of cupric hydrate, and in 1923 the phosphoric acid was also determined.

The Yield and Composition of the different Pasture Cuttings of each Grass.

Table A in appendix gives the dates of cutting, the yield of dry matter at each cutting, together with the percentage composition of the dry matter of that cut for both seasons.

Owing to the area cut being small, and these particular weights not being based on duplicate plots, too much importance cannot be attached to the yields. They are, however, included, because in the main they agree with results obtained from duplicated plots and other trials carried out with the same grasses in the same season, and for this reason we feel justified in drawing from them certain broad deductions.

From these Tables it will be seen that Meadow Fescue, Red Fescue, Tall Fescue, Golden Oat Grass and Crested Dog's Tail, although not producing the greatest weights of dry matter for grazing purposes, and judged of course by these figures, appear to be the most consistent in yield throughout the growing period. It should, however, be borne in mind that all the grasses were cut at the same date irrespective of whether they were then at the same stage of growth.

The grasses producing the greatest weight of dry matter for grazing are the Cocksfoots, Meadow Fescue, Meadow Foxtail, Tall Fescue, and the two Perennial Rye Grasses, which on comparison will be found to agree closely with the green weights from duplicated plots given in the preceding paper (see Table XXIX., p. 77).

The composition of the dry matter of the monthly cuts of one and the same grass, is seen to vary within wide limits. If, however, a general survey of the composition of the dry matter of all the grasses for the two seasons is made, it will be noted that the protein content from month to month fluctuates generally in a manner similar for all up to the middle of August ; subsequent to this date they diverge : the 1922 cuts rising, whereas the 1923 fall. This drop, however, would most probably have been followed by a rise had it been possible to take a later cutting. Evidence in support of this is, we think, supplied by the results of the stem and leaf analysis later discussed.

In considering the chemical composition of these grass cuts, it has to be borne in mind that each cut represents the yield and composition of that growth of grass made between the specified dates ; consequently, there is not that change

in composition one associates with a grass that is cut at different stages of maturity, such as a gradual narrowing of the ratio of true to crude protein and a steady increase in the percentage of fibre.

To complete a year's cycle the result of the analysis of cuts taken in the second season (1923) in the months of November, January and March are included in Table A (in appendix), but these three cuttings are not taken into consideration when the two seasons are compared.

FIGURE I.—*Shows in the form of a graph the average protein content (crude and true) of the different pasture cuts in* 1922 *and* 1923.

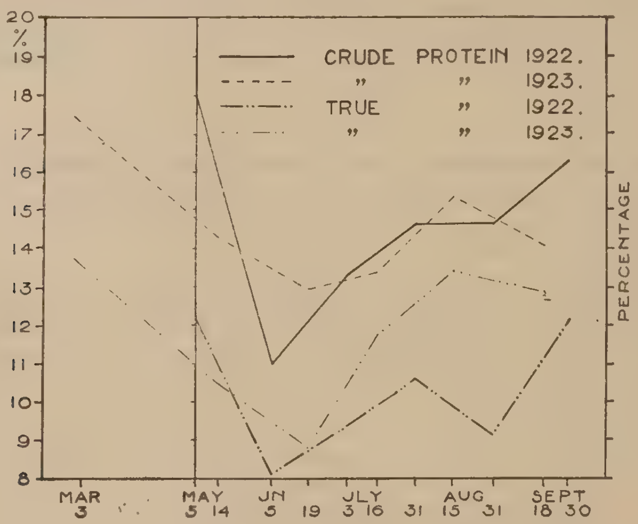


Fig. 1 represents the average rise and fall of the percentage of protein in the dry matter of the grasses during the two seasons, and shows that in 1923 the protein is not subject to such wide variations as it is in 1922. The protein in 1922 is at its highest in the first cutting, and at its lowest in the second. After this there is a constant increase to a figure at the last cutting which closely approaches that found in the first, and in the case of the two Rye grasses and the two Timothys, as reference to Table A (in appendix) shows, actually exceeds it.

In 1923 the protein content of the different cuts of the grasses is as already mentioned more constant, the minimum being found in the second cutting and the maximum in the fourth (August). If the cuttings taken previous to May 14th be taken into account it will be seen, as depicted on the dotted portion of the graph (see Figure I), that the maximum this year is found in the March cutting.

A striking feature of the 1922 graph (Figure I) is the very low protein content in the June cut which produces the maximum weight of dry matter, whilst the August maximum in protein in 1923 coincides with a drop in yield. Moreover, if graphs of the yield be made it is seen that the protein content in both seasons varies generally as the yield rises or falls. Not only does this

generalisation hold for average values but it is maintained also in the majority of the individual grasses, deviation from this occurring only in some of the cuts taken towards the end of the season when the proportion of stem to leaf is low. Indeed it can be safely asserted that the low protein content of the June cuts is due in large measure to the preponderance of stem in the yield.

The total weight of protein produced by each grass in both seasons has been calculated, and is shown in Table I., which, in addition, includes the weight of fibre, ash and silica.

TABLE I.—*Giving in grams the total yield of dry matter, crude and true protein, fibre, ash and silica obtained from one square yard of each grass in the two seasons.*

	Yield of dry matter.		Crude Protein.		True Protein		Fibre.		Ash.		Silica.	
	1922	1923	1922	1923	1922	1923	1922	1923	1922	1923	1922	1923
Cocksfoot U.S.A. ..	423	293	60.7	48.2	43.2	30.1	122	89	37.2	25.8	13.8	10.5
Cocksfoot Indigenous	456	377	56.4	57.4	38.5	45.9	123	110	41.1	45.8	14.0	20.6
Perennial Rye Grass (Danish)	421	215	50.9	26.9	36.8	22.2	100	55	46.5	22.2	18.6	7.5
Perennial Rye Grass, Indigenous ..	399	154	54.6	20.1	38.8	16.8	104	38	38.9	19.0	13.7	9.9
Timothy U.S.A. ..	279	221	34.7	24.3	25.1	19.6	69	55	21.2	21.2	7.0	12.5
Timothy (Indig.) ..	280	132	32.5	16.1	22.3	12.3	65	35	26.4	11.6	10.7	4.2
Tall Oat Grass (French)	222	233	32.8	37.1	19.7	23.0	64	61	16.9	23.5	5.4	9.7
Tall Oat Grass, Indig.	157	172	24.7	26.9	17.1	20.9	38	42	15.8	18.3	5.7	7.6
Golden Oat Grass ,,	249	223	36.3	32.6	26.3	25.3	64	56	25.0	25.0	9.4	12.7
Crested Dog's Tail ,,	238	200	29.3	25.7	22.6	17.9	59	55	22.4	13.6	10.4	4.7
Red Fescue ,,	254	164	32.3	24.7	23.6	19.0	68	46	25.4	14.9	12.7	6.9
Meadow Fescue ,,	357	262	50.7	35.2	35.2	28.5	97	72	40.5	24.8	18.7	11.2
Tall Fescue ,,	343	227	39.7	29.3	26.9	22.7	98	60	31.3	20.2	12.9	9.1
Meadow Foxtail ,,	400	332	54.4	47.7	40.5	36.0	107	89	35.4	34.6	14.3	11.8

The table shows that in both seasons the grass producing the greatest weight of dry matter generally produces the greatest weight of protein ; thus the two Cocksfoots and Meadow Foxtail stand pre-eminently above the remainder, though in 1922 they are closely followed by the two Perennial Rye Grasses and Meadow Fescue ; similarly indigenous Timothy, Tall Oat Grass and Red Fescue with the lowest yield of dry matter, produce the lowest weight of protein. This is, however, by no means without exception, as is seen on comparing the two Cocksfoots and the two Perennial Rye Grasses amongst themselves and indigenous Golden Oat Grass with the two Timothys. A more reliable means of comparing the intrinsic value of the grasses as pasture is supplied in Table 2, where the composition of equal weights of the grasses is given.

Whilst heavy yielding grasses such as the two Cocksfoots and Meadow Foxtail might be expected to give a high total of protein (Table I.), it is perhaps worthy of note that these same grasses appear in Table II. to be amongst those richest in this constituent, thus combining high yield with high quality. Similarly the two Timothy grasses combine a low yield with a comparative poverty in protein. But this relation of yield with quality is not general, for

TABLE II.—*Gives the calculated weight of crude protein, true protein, fibre, ash and silica, contained in 100 grams of dry matter of each of the grasses.*

	Crude Protein		True Protein		Fibre.		Ash.		Silica.	
	1922	1923	1922	1923	1922	1923	1922	1923	1922	1923
Cocksfoot U.S.A. ..	14.3	16.4	10.2	10.3	26.9	30.3	8.8	8.8	2.9	3.6
Cocksfoot Indigenous	12.4	15.2	8.5	12.2	28.9	29.2	9.1	12.1	3.3	5.5
Perennial Rye Grass (Danish)	12.1	12.5	8.7	10.3	25.8	25.6	9.0	10.3	3.4	3.5
Perennial Rye Grass (Indig.)	13.7	13.1	9.7	10.9	23.7	24.8	8.8	12.3	4.4	6.4
Timothy U.S.A. ..	12.5	11.0	9.0	8.9	25.3	24.7	7.6	9.6	2.9	5.6
Timothy Indigenous	11.6	12.2	8.0	9.3	22.6	26.6	9.8	8.8	3.8	2.1
Tall Oat Grass (French)	14.8	15.9	8.9	9.9	24.3	26.4	10.1	10.1	3.9	4.2
Tall Oat Grass, Indigenous ..	15.8	15.6	10.0	12.1	28.6	24.2	7.6	10.6	2.4	4.5
Golden Oat Grass ,,	14.6	14.6	10.6	11.5	26.4	25.2	10.2	11.2	3.8	5.7
Crested Dog's Tail ,,	12.3	12.9	9.6	9.0	24.8	27.3	9.4	6.8	4.4	2.4
Red Fescue ,,	12.7	15.1	9.3	11.6	26.3	27.8	10.4	9.0	5.0	5.5
Meadow Fescue ,	14.2	13.4	9.8	10.9	25.3	27.5	11.4	9.5	5.3	4.3
Tall Fescue ,,	11.6	12.9	8.0	10.0	28.6	26.5	9.7	8.9	3.8	4.0
Meadow Foxtail ,,	13.6	14.9	10.1	10.9	26.9	26.9	8.9	10.4	3.7	3.8

it will be found that Indigenous Tall Oat Grass and Golden Oat Grass, neither of which is a particularly high yielder, compare more than favourably with Cocksfoot and Meadow Foxtail as regards richness in protein.

Taking next the fibre content of the different cuts of grasses from (Table A. appendix) it is seen that as the season advances the percentage of fibre varies similarly in the majority of the grasses.

In 1922 the minumum is found in all cases in the first cutting (May 5th), and the maximum in the second (June 5th), the difference between them being about 8 per cent. The maximum in 1923 is also found in the second cutting (June 19th), but the minimum in the last.

Table I., giving the total weight of fibre produced by each grass in the two seasons, shows that as in the case of protein the heavy grasses generally produce the greatest weight of fibre.

Table II. shows that the two Cocksfoot are outstanding in fibre and that Meadow Foxtail and Danish Perennial Rye Grass are fairly constant in both seasons.

As in the case of protein and fibre the variations in ash and silica are very similar in 1923 to what they were in 1922, the minimum being found at the end of May and the maximum at the end of the season.

SUMMARY AND DISCUSSION OF PASTURE RESULTS.

1. Generally speaking it may be said that the grasses producing the greatest yield, produce the greatest weight of nutrients, though this is not without exception.
2. Amongst the most consistent of the grasses for grazing are the three Fescues, Indigenous Golden Oat Grass and Crested Dog's Tail.

3. The growth of the grasses towards the time of hay cutting, appears to make a special effort to produce seed with the result that there is an increase in the stem of that cut.

4. From May on as the season proceeds it was noted that the proportion of leaf to stem became larger and larger in each cutting, with the result that there is a general tendency for the composition of the cuts to improve.

5. As the different cuts represent new growth it may be presumed that the factor of digestibility is not of such vital importance in a comparison of the grasses, it being generally maintained that all the constituents of a young plant are more digestible than in the same plant of greater age.

6. Of all the grasses experimented with, indigenous Meadow Foxtail and indigenous Golden Oat Grass produce pasture of the highest quality.

Chemical Composition of the Grasses as Hay.

Table B (in appendix) gives the date of cutting, yield of dry matter as well as the chemical composition of the dry matter of the grasses as hay.

The time fixed upon for cutting the grasses was four days after they had reached their maximum flowering, or as near to this as the weather permitted. The first grass in both seasons to reach this stage of maturity was Meadow Foxtail, and the last indigenous Timothy, the interval between them being roughly two months.

From the table it is seen that the yield of dry matter of most grasses is greater in 1922 than in 1923, a result that might be expected when the cutting this portion of the plot was subjected to in 1922 is remembered. It will be recalled that when the grazing properties of the grasses were discussed, attention was drawn to the persistency of Crested Dog's Tail, Red Fescue and Meadow Fescue, and the same three grasses with Danish Perennial Rye Grass give a greater yield of hay in 1923 than in 1922, amounting to nearly three times as much in the case of Red Fescue.

The two grasses, Golden Oat Grass and Tall Fescue, give a greater green weight in1923 than in 1922, but when this is converted to dry weight the advantage is more than counterbalanced by their high water content, a characteristic of all the grasses in the second season when compared with the first.

The chemical composition of the same grass as hay is found to agree closely in both seasons, due probably to the fact that the grasses were cut at as near as possible the same stage of growth. In no case, for example, do we find a difference of more than two per cent. in their protein content, the higher percentage as a general rule being found in the second season. The same close agreement is found in the percentage of mineral matter, though the fibre and silica are subject to wider differences.

Of all the grasses indigenous Meadow Foxtail is outstanding in its protein content, in which it approaches that of clover hay. Golden Oat Grass* and indigenous Tall Oat Grass are also consistently high in protein. The two Cocksfoots are characterised by their high fibre content.

The striking similarity in chemical composition of the grasses as hay apart from Meadow Foxtail, is especially marked when contrasted with the

* It is of particular importance to bear in mind that the Golden Oat Grass under chemical investigation was indigenous—the indigenous strain of this species being altogether more leafy than the non-indigenous.

variation found in the composition of any one of the monthly cuts of all the grasses as pasture cuts. It is also of interest to note the resemblance in composition of the hay of any one grass and that of the pasture cut of the same grass taken at the nearest date to the time of its cutting as hay—the hay of indigenous Cocksfoot in 1922 and the pasture cut of the same grass taken on the 5th of June, 1922—the whole suggesting that the grass cuts for grazing made an effort at this period to produce seed.

A comparison of the nutritive value of the indigenous and commercial varieties of the grasses as hay show that in almost every case the former are slightly superior. Judged either by their percentage composition or by the weight of nutrients produced, the indigenous varieties with the one exception of Timothy in 1922 appear to be superior to the commercial for hay making.

Chemical Composition of the Grasses as aftermath.

Table C (in appendix) gives the date of cutting, yield of dry matter, together with the percentage composition of the dry matter of the aftermath of each grass.

The aftermaths in both seasons were all cut in the same month. The yield of some of the grasses when their yield of hay is taken into consideration is relatively high ; particularly is this the case with the three Fescues and Meadow Foxtail, though in the case of the last named grass a high yield is to be expected, seeing that it had a longer period of growth.

The percentage of dry matter is seen to be very constant in both seasons. The protein on the other hand is subject to fairly wide variation when the aftermaths in any one season of the different grasses are compared. This constituent, as in the case of hay, is on the whole higher in 1923 than in 1922, the percentage in indigenous Tall Oat Grass being a notable instance. The three Fescues and Meadow Foxtail, however, have a higher percentage of protein in 1922 than in 1923, whereas the fibre content of the same grasses is higher in the latter season.

One of the essential differences between hay and aftermath is that the latter has a higher proportion of leaf to stem than the former. One would consequently expect the aftermath to bear a closer resemblance in its chemical composition to pasture than does hay.

A comparison of Tables B and C with A will show this to be the case ; thus the fibre content of the aftermath is distinctly lower than that of the hay, whilst the amounts of protein (both crude and true), ash, silica and phosphoric acid are higher in the aftermath than in the hay.

As was found to be the case with hay so it is with aftermath ; on the whole the aftermaths of the indigenous types are slightly superior in composition to those of the commercial.

SUMMARY OF HAY AND AFTERMATH RESULTS.

1. The lower yield of dry matter of hay in 1923 is probably due to the excessive cutting of this portion of the plot in 1922.
2. The most consistent yielders are Perennial Rye Grass, Crested Dog's Tail. Red Fescue and Meadow Fescue, the last three being in addition the most persistent pasture yielders.

3. A similarity is noted between the composition of the hay cut of a grass and that of its pasture cutting taken at the corresponding date.
4. Indigenous Meadow Foxtail in both seasons appears to produce the highest quality hay, and in addition gives a high total of nutrients, Indigenous Golden Oat Grass being only slightly inferior.
5. Indigenous types produce hay slightly superior in composition to that produced by the commercial type.
6. The aftermath differs from hay in having a greater proportion of leaf to stem ; its chemical composition consequently more closely resembles that of pasture.

A COMPARISON OF THE GRASSES AS HAY AND AFTERMATH WITH THAT OF THE SAME GRASSES FOR PASTURE.

The combined yield of dry matter produced by the hay and aftermath of the majority of the grasses is greater than the dry matter produced by the pasture cuts of that grass. The exceptions in these plots were Commercial Perennial Rye Grass, Crested Dog's Tail and Red Fescue in 1922 and Commercial Cocksfoot and Tall Oat Grass in 1923.

Even though the combined total dry matter of hay and aftermath generally exceeds that of the pasture, it does not follow in all cases that the total protein is higher ; for in the case of indigenous Cocksfoot and Commercial Timothy in 1923, and of indigenous Timothy in 1922, the total protein produced by hay and aftermath is less than that given by a smaller yield of pasture.

The amount of phosphoric acid and mineral matter removed by hay and aftermath from the soil is greater than that removed by pasture, and this becomes still more pronounced when it is realised that a percentage of the latter is returned by the animal to the soil under grazing conditions.

The relative value of Leaf and Stem of Grasses as shown by their Chemical Composition.

If it be assumed that animals graze the blade portion of the plant in preference to the stem, it will be clear that a knowledge of the yield and chemical composition of these portions would be very useful in appraising the merits of the different grasses as pasture, and in ascribing a value to a grass which its analysis as a whole does not provide.

The grasses chosen for separation into leaf and stem were grown in rows of single plants and not in plots as was the case with the fourteen grasses already dealt with. The separation was not a true morphological division, the leaf being cut off at the ligule. These separations were made in The Botanical Laboratories, and the method is fully discussed in the previous paper.* The samples of leaf and stem thus obtained have the advantage of being absolutely free from weeds, a condition very difficult to obtain with broadcast plots, or with plots established with a view to imitating broadcast conditions.

The same determinations were carried out in the analysis of leaf and stem as were made with the grasses. In 1922 the only grass so examined was Cocksfoot (experiment B.108), five lots of different nationalities were grown in a series

* See p. 13.

of rows and cut every three weeks for a period of over five months, commencing on the 19th April. As the yield produced by one row was insufficient for a chemical analysis it was decided to pool the produce from four or five rows of the one type at each cutting.

In 1923 the examination was extended to embrace Perennial Rye Grass and Timothy in addition to Cocksfoot, but in this season only five or six cuttings were made at intervals of a month and six weeks respectively, and as the periods of growth varied, each grass is discussed individually.

The Yield and Composition of Stem and Leaf separations.

A.—Cocksfoot, 1922.

Nationalities :—Indigenous, New Zealand, French, Danish and Swedish.

FIGURE II.—*Shows the rise and fall in yield of leaf and stem of the five types of Cocksfoot cut at each of nine three weekly periods*, 1922.

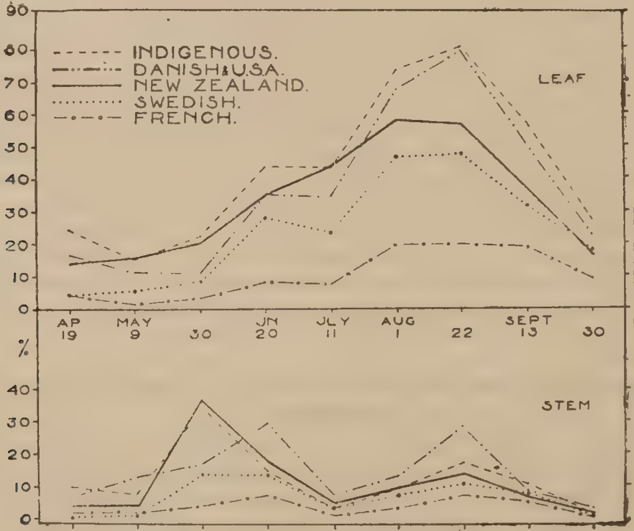


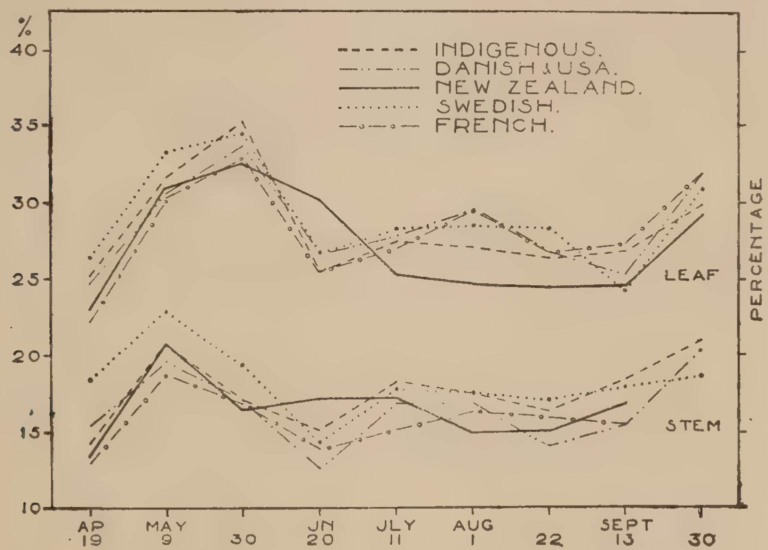
Figure II. represents the rise and fall of leaf and stem respectively for the five types, and shows that the production of leaf varies similarly in all, the minimum leaf yield of the second cutting (9th May) is followed by a continuous in-increase to the maximum reached at the seventh cutting (August 22nd). The stem production on the other hand shows a maximum in the third or fourth cutting (early June) and a minimum in the last cutting. The low yield of stem on the 11th of July is interesting in that it is accompanied by a relatively high yield of leaf, the succeeding cuts showing a distinct increase in amount of stem coinciding with the maximum leaf production.

The ratio of stem to leaf is subject to considerable variation during the season, the fluctuation being very similar for the five types. This ratio in every variety is lowest in the fifth cutting (July 11th) and highest in the third

(May 30th). The high proportion of stem at this date confirms the statement already made (page 89) when discussing the influence of stem preponderance on the chemical composition of a pasture cut.

Whereas it is roughly true that the ratio of stem to leaf at any cutting date is approximately the same for each type, it will be seen from the figure that this ratio is highest for Danish and lowest for indigenous except in the third cutting, New Zealand also showing a very high ratio at this date.

FIGURE III.—*Shows the percentage of crude protein in leaf and stem of the five types of Cocksfoots cut at each of nine three weekly periods* 1922.



The variations of the protein content of leaf as of stem is seen both in the Table D appendix and Figure III. to be very similar in the five types. In the case of leaf the maximum is found in the cutting of May 30th and is followed by a sharp decrease in the succeeding period. It will be noticed that this decrease in protein content is accompanied by a sharp increase in leaf production, which at first sight appears to be contradictory. This, however, is not unexpected, for there appears in all this work to be a suggestion that when the yield of either stem or leaf is high the general tendency is for the protein to fall. A good example of this is seen in the stem of the Danish variety, where each increase in yield is accompanied by a fall in the protein content and *vice versa*.

The maximum protein content of the stem is found in the cut (9th May) preceding that in which it is found in the leaf (30th May), and apart from this the rise and fall of protein in both leaf and stem are very similar. If a comparison of the five types is made the Swedish variety (Svalof Scandia) in both stem and leaf is a little richer in protein.

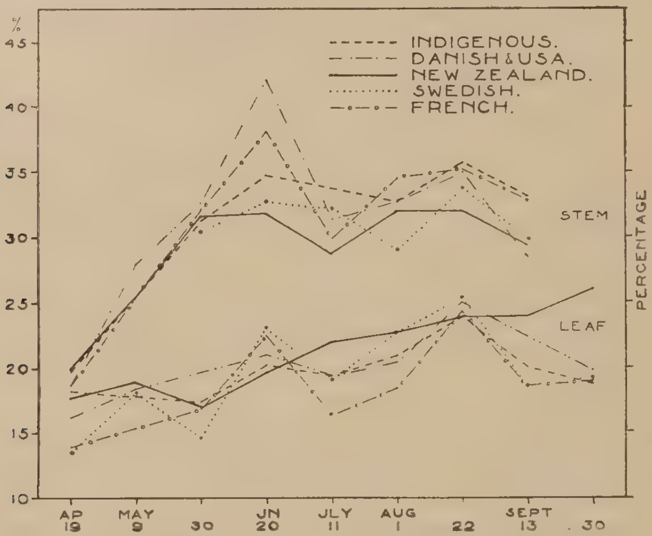
Without exception it is found that in the leaf the true protein forms a higher percentage of the crude protein than it does in the stem. This percentage

whilst maintaining the fairly constant value of 88 until the beginning of August, falls to a minimum in all the types in the cutting of August 22nd. Suggesting that the growth during early August is of a less mature character, and this we think is borne out when the composition of the pasture cuts for the corresponding periods are consulted.

Reference to Figure III. brings out the marked superiority in protein of leaf over stem at every cutting; never is the difference between them less than 8 per cent., and in the cutting of May 30th it amounts to over 15 per cent.

The advantage which leaf has over stem is still further emphasised in Figure IV. showing graphs of fibre variation.

FIGURE IV.—*Shows the percentage of fibre in leaf and stem of the five types of Cocksfoots cut at each of nine three weekly periods.* 1922.



Comparison of the two series of graphs shows that except in the first cutting (April 19th) when the difference is insignificant, the amount of fibre in the stem portion of the plant greatly exceeds that found in the leaf, especially in the cutting of June 20th. In both leaf and stem, though more particularly in the latter, an increase in yield is generally accompanied by a more fibrous product, except for the third period, when a decrease in yield of stem is associated with a decided increase in fibre content.

It is interesting to note that the amount by which the protein of the stem is lower than that of the leaf, is approximately equal to the amount by which the fibre of the stem exceeds that of the leaf, except in the first cutting and to a lesser degree in the second, when the difference appears mainly as soluble carbohydrates.

B. Cocksfoot, 1923.

As in the previous year the nationalities of Cocksfoot in 1923 were grown in rows of single plants, the station number of the experiment being B.56 II.

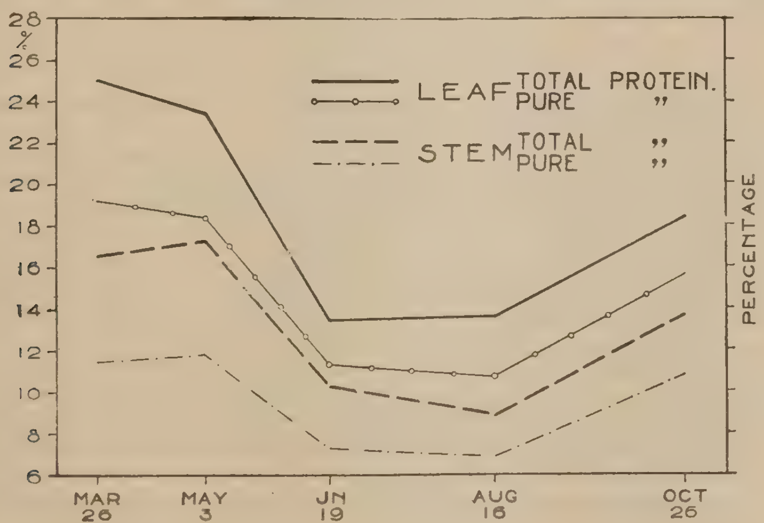
The nationalities were American, French, Ayrshire (*ex* Danish) and three Indigenous.

The period between each cutting was six weeks, the first being taken on March 26th and the last on October 26th. The results of the analysis are given in Table E appendix, and in the main will be found to confirm the difference in composition between leaf and stem established by the 1922 results.

It will be observed that in the first cutting the separation was carried a step further, the brown portion of the leaf being separated from the green, and the composition of the dry matter of each determined. Apart from this cutting the separation was carried out as in the previous year.

The main characteristics of the " burn " portion of the leaf in each variety when compared with either the stem or the green portion of the leaf, are, a high ash and silica content and a low percentage of protein and of phosphoric acid. We feel that the close similarity in composition of each cutting of the six types justifies us in averaging the whole for the purpose of discussion. Figure V. shows in the forms of graphs the average protein both crude and true of leaf and of stem.

FIGURE V.—*Shows the average percentage of crude protein in leaf and stem of six types of Cocksfoot cut at each of five six weekly periods,* 1923.



When the cuttings are six weekly, as is the case with the grass under consideration, the differences between the protein content of the leaf and that of the stem in July and August are less than when the cuttings are taken more frequently (see Fig. V. and Fig. III), although the total protein is much higher when the grass is frequently cut.

The maximum amount of protein in both leaf and stem is found in the spring, and the minimum in July and August. It is to be noted that the percentage of protein rises towards the end of the season, as is also the case with Perennial

Rye Grass and Timothy, which are later discussed, and gives support to the assumption made in page 87 when dealing with the protein content of pasture cuts.

The differences in the percentage of fibre in the stem and leaf is greatest in the June cutting (Table E), when it reached its maximum in the stem; this was also found to be the case in Cocksfoot, 1922 (see Fig. IV.). These differences, however, are found to disappear in the succeeding cuts.

The ash and silica in 1923 do not increase as in 1922, but retain a fairly high value throughout the season, and the percentage in leaf and stem at each cutting are somewhat similar except in June, when the mineral matter in the leaf, as was the case in the majority of cuts in 1922, is distinctly higher than in the stem, again as in 1922 the phosphoric acid is higher in the stem than in the leaf.

C.—Perennial Rye Grass and Timothy, 1923.

The results of a few monthly cuttings of some nationalities of Perennial Rye Grass and of Timothy are found in Table F appendix.

They are included because they confirm the chief conclusions arrived at in the preceding sections concerning (*a*) The differences between leaf and stem in composition, (*b*) The increase in protein content towards the end of the season, and (*c*) The high fibre content of the stem portion in the months of June or July.

SUMMARY OF LEAF AND STEM RESULTS.

The data in 1922 being more complete than in 1923, the following summary is based mainly on the 1922 results :—

1. The proportion of stem to leaf is highest in June and lowest in July.
2. The composition of the leaf portion in all cases is far superior to that of the stem; the difference is least in early spring and early autumn.
3. This superiority is most marked in a higher percentage of protein and a lower amount of fibre.
4. The ratio of true to crude protein is higher in the leaf than in the stem.
5. In both leaf and stem an increase in yield of dry matter is accompanied by a more fibrous product.
6. The percentage of ash and silica in leaf exceeds that of the stem, but the phosphoric acid is slightly higher in the stem than in the leaf.
7. The differences between leaf and stem in protein are less marked when cuttings are made at intervals of six weeks than when the cuttings are more frequent, though the percentage of protein is higher in the latter case.
8. The percentage of protein in both leaf and stem increases towards the end of the season.

General Conclusions.

At the outset it was stated that one of the objects of this work was to obtain information on the basis of chemical analysis of the relative value of the different grasses as pasture or as hay. We fully realise that where such a number of factors is involved, a determination of the chemical composition is but a small contribution to a knowledge of the suitability of the grasses for either or both purposes. In as much as there is such a general agreement between the

results of the two seasons, it may be anticipated that further work on these lines may lead to some useful distinction being drawn between the various grasses.

In order to assess the intrinsic value of the individual grasses, it is necessary to possess a knowledge of at least four factors, viz. : yield, persistency, composition and digestibility. Any attempt at determining the last was out of the question as the produce was too small ; but confined though we are in the valuation of the grasses to the first three factors, we think that there is strong evidence in favour of the view that for hay making, judged merely by quality and yield of the hay and aftermath, indigenous Meadow Foxtail is the best of the fifteen grasses examined.* The less productive indigenous Golden Oat Grass is only slightly inferior in quality, the high yielding Cocksfoots have the disadvantage that the hay produced is of a decidedly fibrous character. The composition of the hay crops of the remainder of the grasses is so similar in all cases that considerations of yield and persistency are the deciding factors.

With regard to grazing, it can be asserted with some confidence that the leaf portion of the plant is distinctly richer than the stem, and a knowledge of the relative proportions of these parts will prove a fair guide to the nutritive value of a pasture at any period of the year. Indigenous Meadow Foxtail and Indigenous Golden Oat Grass again are amongst the best of the grasses for pasture,† the Tall Oat Grasses, though superior in quality are perhaps not persistent, and this is certainly true of the ordinary French strain. In virtue of a very high yield and of a high protein content the pasture of the two Cocksfoots is valuable despite its high percentage of fibre.

Frequent mention has been made of the persistency of Red Fescue and Crested Dog's Tail, a factor that enhances their value as pasture grasses. This value is established by a fairly high quality despite a rather poor leaf to stem ratio, and if not by high yields, at all events by consistent yielding ability throughout the season. Moreover, the yields of hay and aftermath produced by these grasses, although not as high as that given by the larger grasses, appears to be maintained at a more uniform level from year to year. Little evidence is afforded to enable one to differentiate between commercial and indigenous types, though such as is given by chemical analysis suggests that for hay making the latter are slightly superior to the former, this being doubtless due to the greater contribution made by leaf to the produce.

An indication of the quality of winter pasture is provided by the results of the analysis of winter cuttings of the grasses in 1922—23. The growth during this period is characterised by a high percentage of dry matter rich in ash and silica, showing a rapid increase in protein content with the approach of spring. The low amount of moisture in winter pasture is probably due in part to a large proportion in the yield of brown or "burnt" leaf.

The obvious necessity for determining the digestibility of the produce has not been lost sight of, and it is hoped that at a future date, when larger plots of individual grasses are available, this will be possible.

* It must be remembered of course that under ordinary meadow conditions, Meadow Foxtail flowers so early that the hay is seldom, if ever, cut at the correct time for this species.

† It is interesting to note that indigenous Golden Oat Grass occurs in varying amount on most of the famous fatting pastures of the country. It seldom exceeds a 2 per cent. contribution to the herbage in Leicestershire and Northamptonshire ; is slightly more plentiful in the Blackmoor Vale, but may attain to as much as 8 per cent. in the Romney Marsh. Meadow Foxtail, on the other hand, only occurs in traces on the famous pastures in the districts mentioned.

APPENDIX.

TABLE A.

Date of Cutting.	Yield in grams dry.	Moisture.	Ether extract.	Crude Protein.	True Protein.	Fibre.	Ash.	Soluble carbohydrate.	Silica. ($Si. O_2$.)	Phosphoric Acid. ($P_2 O_5$).
COCKSFOOT—U.S.A. 1922. (Bc. 600).										
May 5th	58.18	80.86	4.30	22.56	11.94	24.45	9.20	39.49	2.95	—
June 5th	206.25	72.48	3.65	11.18	9.06	31.35	5.51	48.31	0.50	—
July 3rd	43.65	67.18	4.70	16.44	10.68	28.35	12.25	38.26	7.25	—
July 31st	57.54	77.78	3.55	14.40	10.81	26.92	11.30	43.83	6.03	—
August 31st	40.80	80.00	3.40	14.87	11.06	27.25	12.61	41.87	5.90	—
September 30th	17.38	74.81	4.25	16.87	12.31	22.61	20.00	36.27	11.50	—
COCKSFOOT—Indigenous 1922. (Bc. 229).										
May 5th	38.60	77.28	6.35	21.81	15.94	19.05	11.30	41.49	5.70	—
June 5th	247.80	72.00	3.25	9.06	7.06	31.04	6.10	50.55	0.50	—
July 3rd	48.58	64.01	3.35	13.44	6.31	23.70	12.85	46.66	7.60	—
July 31st	53.16	81.54	3.90	15.87	9.69	25.50	13.41	41.32	6.14	—
August 31st	45.90	82.16	4.55	14.87	9.69	20.15	11.52	48.91	4.40	—
September 30th	22.55	76.26	4.40	17.56	14.37	22.35	13.70	41.99	6.80	—
COCKSFOOT—U.S.A. 1923. (Bc. 600).										
November 14th, 1922 ..	30	63.53	3.75	11.50	7.12	27.12	13.00	44.63	7.88	0.42
January 1st, 1923	7	72.00	4.70	9.56	6.62	29.52	17.35	38.87	12.69	0.44
March 15th	22	71.63	3.90	23.68	13.87	20.50	18.45	33.47	—	—
May 14th	147	80.50	3.80	17.31	8.00	33.25	5.88	39.76	1.33	0.63
June 19th	52	77.00	3.90	15.87	11.23	28.75	8.88	42.60	1.89	0.62
July 16th	37	75.18	3.50	13.62	12.50	24.40	12.73	45.75	7.17	0.88
August 15th	30	71.22	3.70	16.50	12.50	28.85	12.99	37.96	8.01	0.95
September 18th	27	72.41	4.25	16.69	15.37	25.90	14.50	38.66	9.30	0.80
COCKSFOOT—Indigenous 1923. (Bc. 229).										
November 14th, 1922 ..	40	72.45	4.15	15.69	12.00	26.50	15.43	38.23	9.60	0.45
January 15th, 1923	14	71.52	3.65	14.19	12.19	25.14	15.49	41.53	10.52	0.57
March 3rd	15	68.75	4.25	17.50	16.25	22.00	17.61	38.64	—	—
May 14th	111	76.00	4.30	16.87	12.94	26.00	10.13	42.70	4.50	0.67
June 19th	137	78.00	3.85	13.44	10.25	33.05	11.13	38.53	3.26	0.98
July 16th	58	76.08	4.50	14.94	12.81	26.55	15.33	38.68	7.99	1.05
August 15th	36	76.62	4.15	17.69	14.25	33.50	11.85	32.81	6.75	1.02
September 18th	35	76.03	4.80	15.06	14.00	27.35	17.71	35.08	11.68	0.84

TABLE A.—*continued.*

Date of Cutting.	Yield in grams dry.	Moisture.	Ether Extract.	Crude Protein.	True Protein.	Fibre.	Ash.	Soluble carbohydrate.	Silica. (Si. O_2.)	Phosphoric Acid. (P_2O_5).
PERENNIAL RYE GRASS—Danish 1922. (Ba. 379).										
May 5th	121.22	78.88	4.20	12.75	9.25	18.05	11.25	53.75	3.65	—
June 5th	147.83	75.07	4.95	9.44	7.94	27.04	6.72	51.85	1.15	—
July 3rd	29.12	70.28	3.40	12.87	8.81	25.55	12.95	45.23	7.05	—
July 31st	45.99	79.40	5.87	13.75	9.75	27.15	11.80	41.43	3.81	—
August 31st	33.26	80.88	3.41	13.94	8.87	25.62	10.11	46.92	6.20	—
September 30th	44.40	74.62	4.55	16.06	11.50	22.40	23.50	33.49	15.00	—
PERENNIAL RYE GRASS—Indigenous 1922. (Ba. 378).										
May 5th	25.24	78.05	3.45	18.75	11.12	19.85	11.85	46.10	4.25	—
June 5th	187.47	73.52	4.65	12.06	10.25	28.00	5.90	49.39	0.45	—
July 3rd	60.90	71.00	2.60	11.25	7.43	23.10	14.50	48.55	8.75	—
July 31st	33.72	80.62	3.20	12.87	9.12	26.00	12.06	45.87	4.21	—
August 31st	55.44	79.20	3.92	16.37	8.69	25.15	12.31	42.25	5.11	—
September 30th	36.87	76.21	4.83	18.81	11.81	25.65	13.90	36.81	5.90	—
PERENNIAL RYE GRASS—Danish 1923. (Ba. 379).										
November 14th, 1922 ..	42	67.71	3.14	11.71	10.19	24.25	12.90	48.00	6.26	0.32
January 15th, 1923	12	69.41	5.15	20.19	16.25	24.35	16.56	33.75	8.10	0.59
March 15th	28	72.05	3.25	15.69	12.19	16.50	17.07	47.49	9.89	0.68
May 14th	76	78.50	2.55	10.44	8.00	27.75	7.15	52.11	1.80	0.75
June 19th	77	70.00	3.55	12.75	10.62	24.55	10.58	48.57	3.19	0.62
July 16th	13	71.12	3.55	15.31	12.56	25.80	9.50	45.84	3.57	0.77
August 15th	11	70.03	3.20	15.56	14.12	22.55	12.60	46.09	6.27	0.85
September 18th	38	76.85	3.80	14.44	12.56	23.15	12.27	46.34	6.72	0.63
PERENNIAL RYE GRASS—Indigenous 1923. (Ba. 378).										
November 14th, 1922 ..	67	69.48	3.50	13.62	11.25	26.75	14.08	42.05	8.82	0.63
January 15th, 1923	23	68.32	5.40	19.19	13.19	26.52	14.04	34.85	7.57	0.64
March 15th	35	69.09	4.00	15.69	11.99	18.45	17.03	44.83	10.12	0.70
May 14th	44	78.50	2.85	11.62	7.37	25.50	8.82	51.21	3.20	0.73
June 19th	26	79.15	4.03	12.75	7.25	31.50	9.19	42.53	3.89	0.71
July 16th	50	67.32	2.95	13.50	11.87	23.55	13.39	46.61	8.80	0.73
August 15th	15	78.52	4.10	15.19	14.25	25.80	14.32	40.59	6.22	0.94
September 18th	29	72.85	4.20	14.19	12.41	21.60	14.42	45.59	9.02	0.72

TABLE A—*continued.*

Date of Cutting.	Yield in grams dry.	Moisture.	Ether extract.	Crude Protein.	True Protein.	Fibre.	Ash.	Soluble carbo-hydrate.	Silica. ($Si. O_2$).	Phosphoric Acid. ($P_2 O_5$).
TIMOTHY—U.S.A. 1922. (Bd. 72).										
May 5th	77.15	68.89	4.10	14.50	10.37	20.91	7.40	53.09	2.55	—
June 5th	137.48	74.54	2.75	10.25	7.31	27.50	5.75	53.75	0.75	—
July 3rd	5.72	66.30	4.70	12.87	10.25	27.90	8.00	46.53	2.00	—
July 31st	24.05	76.42	3.85	14.37	11.44	23.70	10.30	47.78	5.30	—
August 31st	23.57	79.50	2.05	15.06	9.69	23.42	11.26	48.21	6.20	—
September 30th	11.39	73.51	4.11	15.37	12.37	22.45	11.90	40.57	10.70	—
TIMOTHY—Indigenous 1922. (Bd. 71).										
May 5th	40.82	70.84	3.95	14.50	9.94	21.92	8.15	51.48	3.82	—
June 5th	119.24	72.90	2.25	9.06	6.25	23.53	7.82	57.34	1.70	—
July 3rd	20.63	65.61	4.25	13.19	10.69	20.00	8.55	54.01	2.73	—
July 31st	38.25	73.06	3.82	12.12	7.75	24.75	8.34	50.97	3.57	—
August 31st	33.12	74.32	3.30	13.00	8.37	23.22	12.56	47.92	7.17	—
September 30th	28.93	72.44	4.62	14.75	9.94	22.65	16.80	41.18	10.10	—
TIMOTHY—U.S.A. 1923. (Bd. 72).										
November 4th, 1922 ..	16	51.62	2.55	8.75	8.37	27.50	12.52	38.88	9.24	0.46
January 15th, 1923	8	56.55	3.25	8.62	6.37	30.55	12.61	44.97	9.37	0.38
March 15th	17	64.59	3.20	14.56	13.00	20.00	13.41	48.83	8.29	0.88
May 14th	116	70.49	3.45	11.43	9.00	20.52	10.71	53.89	8.12	0.56
June 19th	69	77.52	3.51	9.44	7.37	27.06	7.03	52.96	1.70	0.72
July 16th	18	62.73	2.70	12.00	11.18	26.20	11.23	47.87	5.18	0.53
August 15th	11	61.87	4.35	13.50	11.81	25.00	10.48	46.67	5.60	0.66
September 18th	7	65.42	3.20	13.12	11.81	23.95	10.62	49.11	5.83	0.63
TIMOTHY—Indigenous 1923. (Bd. 71).										
November 14th, 1922 ..	16	58.34	3.75	9.37	7.69	26.75	9.00	51.13	5.17	0.33
January 15th, 1923	10	59.92	3.23	7.50	6.31	31.25	9.02	49.00	5.70	0.40
March 15th	7	69.57	3.00	14.19	10.37	23.50	12.12	47.19	7.36	0.71
May 14th	27	74.07	4.95	13.62	13.26	23.50	6.07	51.86	1.13	0.62
June 19th	43	76.02	3.54	12.62	8.12	23.75	8.07	52.02	1.57	0.52
July 16th	26	71.43	3.50	10.44	9.50	26.50	9.00	50.56	4.07	0.73
August 15th	18	62.73	2.55	10.00	9.37	26.80	8.32	52.33	4.25	0.62
September 18th	18	67.26	3.35	13.62	11.81	16.45	14.63	51.95	7.65	0.75

TABLE A.—*continued.*

Date of Cutting.	Yield in grams dry.	Moisture.	Ether extract.	Crude Protein.	True Protein.	Fibre.	Ash.	Soluble carbohydrate.	Silica. ($Si. O_2$).	Phosphoric Acid. ($P_2 O_5$).
TALL OAT GRASS—French, 1922. (Bm. 26).										
May 5th	45.12	80.80	4.95	17.87	11.25	21.85	7.20	48.13	1.70	—
June 5th	109.51	71.92	2.75	13.37	7.06	31.55	5.25	47.08	1.00	—
July 3rd	9.95	63.14	4.50	17.37	11.87	26.86	8.80	42.47	4.11	—
July 31st	24.16	78.80	3.45	13.50	8.12	29.05	9.05	44.95	3.22	—
August 31st	21.43	76.19	2.62	15.37	8.87	31.25	10.93	39.83	3.86	—
September 30th	13.24	75.91	4.22	16.37	14.00	21.00	19.00	39.41	11.50	—
TALL OAT GRASS—Indigenous 1922. (Bm. 25).										
May 5th	17.79	77.76	3.90	19.50	13.56	19.60	10.50	46.50	4.50	—
June 5th	60.30	73.20	5.00	13.56	9.69	25.92	6.80	48.72	1.05	—
July 3rd	11.22	59.92	4.21	13.50	10.25	20.69	9.50	52.10	3.51	—
July 31st	22.13	75.13	4.80	17.43	13.25	20.11	10.33	47.33	4.87	—
August 31st	29.98	79.60	4.15	15.94	8.75	26.31	12.32	41.28	4.85	—
September 30th	16.48	72.53	4.35	17.37	13.31	25.12	16.40	36.76	9.40	—
TALL OAT GRASS—French 1923. (Bm. 26).										
November 14th, 1922 ..	25	68.28	3.80	12.06	10.19	25.75	14.88	43.51	10.00	0.47
January 15th, 1923	7	70.52	4.53	20.87	14.44	20.28	15.89	38.43	9.66	0.79
March 15th	23	76.34	4.20	19.25	16.81	15.05	15.61	45.89	8.65	0.93
May 14th	110	77.96	2.75	18.25	9.87	28.12	6.80	44.08	1.48	0.90
June 19th	52	74.00	4.21	14.69	7.25	26.15	10.97	43.98	3.05	—
July 16th	37	67.15	3.00	13.37	11.87	23.90	15.18	44.55	9.80	0.76
August 15th	10	68.76	4.50	15.81	14.44	27.25	9.50	42.94	4.04	0.75
September 18th	24	68.83	3.40	12.06	10.42	20.85	15.87	47.82	10.41	0.67
TALL OAT GRASS—Indigenous 1923. (Bm. 25).										
November 14th, 1922 ..	13	71.11	3.25	8.19	7.69	26.42	14.70	47.44	6.47	0.35
January 15th, 1923	9	70.05	3.56	16.87	13.25	23.54	15.51	40.52	9.81	0.62
March 15th	14	77.78	6.70	23.93	17.75	15.75	15.09	38.53	7.87	0.97
May 14th	78	78.32	4.35	16.25	13.50	24.00	8.84	46.56	2.95	0.83
June 19th	58	77.15	4.25	15.62	10.25	26.80	9.66	43.67	2.44	1.16
July 16th	14	64.53	3.00	12.56	12.00	21.00	15.48	47.96	10.69	0.79
August 15th	8	67.35	3.50	16.50	14.00	21.95	16.60	41.45	10.58	0.79
September 18th	14	70.20	3.85	14.62	12.50	18.15	16.80	46.58	10.67	0.74

TABLE A.—*continued.*

Date of Cutting.	Yield in grams dry.	Mois- ture.	Ether extract.	Criude Protein.	True Protein.	Fibre.	Ash.	Soluble carbo- hydrate.	Silica. (Si. O_2).	Phos- phoric Acid. (P_2O_5).
GOLDEN OAT GRASS—Indigenous 1922. (Bs. 98).										
May 5th	16.91	78.86	4.80	23.62	16.37	20.45	12.85	38.28	5.85	—
June 5th	112.78	71.08	4.00	11.56	8.75	27.73	6.25	50.46	1.50	—
July 3rd	22.25	68.21	3.40	12.81	10.81	21.95	14.15	47.69	4.05	—
July 31st	21.09	77.32	4.10	16.81	11.94	24.75	13.50	40.84	6.21	—
August 31st	40.53	80.61	3.83	15.69	10.62	29.51	11.90	39.07	4.90	—
September 30th	36.14	74.18	4.55	18.56	12.50	23.92	14.40	38.57	7.00	—
GOLDEN OAT GRASS—Indigenous 1923. (Bs. 98).										
November 14th, 1922 ..	23	68.61	3.15	11.25	9.56	22.00	13.74	49.86	10.50	0.47
January 15th, 1923	4	66.64	—	10.81	8.19	—	—	—	—	—
March 15th	20	68.26	3.15	18.50	12.37	18.50	18.82	41.03	12.13	0.50
May 14th	51	76.11	6.55	17.62	14.06	27.85	7.81	40.17	2.13	0.83
June 19th	87	75.00	3.75	12.06	9.12	27.58	8.70	47.91	3.12	0.73
July 16th	35	68.38	2.15	13.25	10.68	23.00	13.22	48.38	8.11	0.69
August 15th	20	69.21	4.15	17.00	13.75	24.15	13.90	40.80	8.15	0.84
September 18th	30	70.17	4.20	14.81	12.75	16.75	20.27	43.97	14.87	0.74
CRESTED DOG'S TAIL. 1922. (Bg. 75).										
May 5th, 1922	21.98	68.59	4.65	16.56	11.81	21.70	9.50	47.59	4.65	—
June 5th	104.17	69.36	3.50	9.31	8.06	28.55	4.95	53.69	1.95	—
July 3rd	21.12	67.50	2.20	10.50	9.19	20.00	12.35	54.95	7.10	—
July 31st	17.89	72.88	3.20	14.19	11.50	21.82	12.50	48.29	6.53	—
August 31st	42.64	74.00	3.65	14.75	9.31	20.61	11.42	49.57	4.22	—
September 30th	30.57	76.11	4.52	16.31	12.00	23.93	17.90	37.34	9.50	—
CRESTED DOG'S TAIL. 1923. (Bg. 75).										
November 14th, 1922 ..	28	62.67	2.52	12.50	11.69	16.25	14.42	54.31	10.02	0.40
January 15th, 1923	17	62.22	4.02	15.87	14.44	17.56	11.11	51.44	6.01	0.46
March 15th	18	71.43	3.00	16.62	12.19	21.25	14.09	45.04	6.76	0.63
May 14th	54	70.74	3.45	15.94	11.06	21.91	7.22	51.48	2.48	0.83
June 19th	83	73.06	2.95	9.56	5.19	34.25	5.58	47.66	1.18	0.63
July 16th	28	69.90	3.00	14.25	11.50	22.85	10.54	49.36	4.60	0.65
August 15th	17	73.85	4.00	15.31	12.81	23.10	12.27	45.32	6.26	0.74
September 18th	—	72.18	3.95	16.75	14.81	17.75	13.60	47.95	6.55	0.60

TABLE A.—*continued.*

Date Cutting.	Yield in grams dry.	Moisture.	Ether extract.	Crude Protein.	True Protein.	Fibre.	Ash.	Soluble carbohydrate.	Silica. ($Si. O_2$).	Phosphoric Acid. ($P_2 O_5$).
ROUGH STALKED MEADOW GRASS. 1922. (Bk. 79).										
May 5th	26.34	69.01	3.50	15.37	12.06	15.65	13.85	51.63	6.75	—
June 5th	69.27	70.52	2.80	10.75	7.31	29.40	6.70	50.35	2.10	—
July 3rd	15.55	60.11	1.50	9.06	8.12	20.00	14.02	55.42	8.71	—
July 31st	25.62	72.74	2.60	13.50	9.75	22.95	12.51	48.44	6.52	—
August 31st	18.70	76.32	3.05	13.19	7.62	27.35	11.52	44.89	4.76	—
September 30th	33.35	71.25	3.22	14.19	11.18	18.43	15.31	48.85	8.82	—
RED FESCUE. 1922. (Bl. 476).										
May 5th	34.74	74.26	4.90	19.12	14.69	20.55	11.25	44.18	6.25	—
June 5th	87.67	70.48	4.35	11.19	8.68	29.15	6.25	49.06	2.25	—
July 3rd	35.83	64.52	3.15	11.87	7.19	24.75	12.25	47.98	7.75	—
July 31st	36.63	75.08	4.20	11.06	7.50	20.35	13.30	51.09	7.31	—
August 31st	31.81	80.60	3.45	12.87	7.25	30.42	11.63	41.63	4.92	—
September 30th	28.09	71.91	3.92	16.44	11.56	27.74	11.25	40.65	5.41	—
RED FESCUE. 1923. (Bl. 475).										
November 14th, 1922 ..	21	75.49	3.53	9.88	8.99	24.25	13.88	48.46	9.10	0.49
January 15th, 1923	10	75.61	4.55	13.50	9.75	27.49	11.49	42.97	7.00	0.53
March 15th	9	67.86	3.85	15.75	13.12	21.75	14.39	44.26	8.37	0.60
May 14th	40	72.87	3.12	11.06	8.50	29.50	5.87	50.45	2.46	0.57
June 19th	40	70.18	3.80	13.56	10.25	29.80	8.71	44.13	4.06	0.67
July 16th	37	68.38	2.55	14.25	11.63	27.05	10.13	46.02	4.97	0.63
August 15th	19	75.28	4.50	16.25	14.87	25.85	9.73	43.67	4.03	0.66
September 18th	28	71.72	5.50	18.25	15.50	24.55	12.54	39.16	6.07	0.79

TABLE A.—*continued.*

Date of Cutting.	Yield in grams dry.	Moisture.	Ether extract.	Crude Protein.	True Protein.	Fibre.	Ash.	Soluble carbohydrate.	Silica. (SiO_2).	Phosphoric Acid. (P_2O_5).
MEADOW FESCUE. 1922. (Bf. 15).										
May 5th	59.78	71.80	6.70	15.87	10.25	20.70	11.30	45.43	5.93	—
June 5th	107.50	77.12	2.50	12.75	8.68	29.10	6.05	49.60	0.75	—
July 3rd	62.74	72.60	1.00	13.19	9.56	23.11	11.50	51.20	8.11	—
July 31st	49.79	74.20	2.95	15.56	12.19	24.30	13.91	43.28	3.92	—
August 31st	45.45	79.80	3.50	14.56	9.37	29.01	12.60	40.33	5.33	—
September 30th	32.20	77.00	4.53	14.25	10.81	22.85	22.90	35.47	15.40	—
MEADOW FESCUE. 1923. (Bf. 15).										
November 14th, 1922 ..	28	68.35	3.10	11.81	9.50	26.52	12.50	46.07	7.44	0.42
January 15th, 1923	8	66.21	2.55	11.16	8.87	30.14	12.58	43.57	9.09	0.39
March 15th	23	65.16	3.52	14.93	13.44	24.25	11.24	46.06	6.93	0.40
May 14th	77	73.67	3.85	15.50	12.75	23.75	8.36	48.54	3.94	0.57
June 19th	84	79.00	3.12	10.94	8.12	31.52	6.53	47.88	1.79	0.59
July 16th	41	74.00	2.85	14.00	12.12	26.05	12.21	44.89	6.18	0.67
August 15th	30	75.84	3.55	15.31	12.75	29.30	11.91	39.93	5.46	0.64
September 18th	30	71.76	3.85	12.44	10.31	26.20	14.37	43.14	8.50	0.82
TALL FESCUE. 1922. (Bn. 18).										
May 5th, 1922	50.52	73.41	3.70	14.31	10.56	23.12	7.75	51.12	3.00	—
June 5th	116.04	77.51	2.44	10.37	5.87	36.15	5.20	45.84	0.71	—
July 3rd	75.14	66.75	2.25	10.12	7.50	23.25	10.55	53.83	3.95	—
July 31st	35.73	70.71	2.50	15.62	11.69	25.65	7.80	48.43	4.12	—
August 31st	42.81	76.08	2.91	11.25	6.87	29.05	10.73	46.06	4.55	—
September 30th	23.20	72.70	4.33	12.25	8.87	22.42	26.30	34.70	19.00	—
TALL FESCUE. 1923. (Bn. 18).										
November 14th, 1922 ..	17	67.39	3.95	11.56	9.62	29.50	11.77	43.22	6.45	0.54
January 15th, 1923	7	65.84	2.00	11.62	9.25	27.14	10.91	48.33	6.71	0.47
March 15th	20	69.23	3.75	14.50	11.69	24.75	11.61	45.39	6.73	0.54
May 14th	79	75.81	5.10	11.63	7.37	21.30	6.71	55.26	2.23	0.62
June 19th	58.0	74.09	3.25	12.75	9.25	30.12	8.57	45.31	2.78	0.79
July 16th	40	71.24	2.50	13.50	12.17	32.90	10.67	40.43	5.16	0.82
August 15th	26	74.31	3.10	15.19	14.25	28.45	11.11	42.15	8.81	0.56
September 18th	24	68.84	3.65	14.19	12.43	21.00	11.51	49.65	5.93	0.86

TABLE A.—*continued.*

Date of Cutting.	Yield in grams dry.	Moisture.	Ether extract.	Crude Protein.	True Protein.	Fibre.	Ash.	Soluble carbohydrate.	Silica. (Si. O_2).	Phosphoric Acid. ($P_2 O_5$).
MEADOW FOXTAIL. 1922. (Bh. 274).										
May 5th	30.03	76.90	4.30	18.87	13.62	17.71	9.75	49.37	4.62	—
June 5th	203.82	70.63	3.51	10.68	8.44	29.65	6.00	50.16	1.75	—
July 3rd	52.12	74.82	3.50	14.93	10.37	23.11	11.52	46.94	6.43	—
July 31st	39.69	76.09	4.40	17.19	13.31	24.75	10.15	45.51	4.66	—
August 31st	48.45	77.67	3.20	16.12	10.12	27.95	12.42	40.31	4.44	—
September 30th	25.77	74.23	4.22	18.00	14.19	23.51	16.50	37.77	8.91	—
MEADOW FOXTAIL. 1923. (Bh. 274).										
November 14th, 1922 ..	57	61.73	3.15	12.06	9.50	22.65	11.72	50.42	8.36	0.46
January 15th, 1923	15	66.14	3.21	11.56	9.50	23.22	10.90	51.11	5.72	0.61
March 15th	22	73.50	4.80	23.56	17.06	18.75	11.55	41.34	6.01	0.66
May 14th	156	77.45	4.75	14.19	10.83	28.80	8.60	43.66	1.97	0.70
June 19th	82	78.00	3.98	14.00	8.68	25.31	12.78	43.93	3.91	0.74
July 16th	58	75.18	3.40	14.87	12.19	25.75	10.50	45.48	4.94	0.82
August 15th	15	62.50	2.90	15.06	13.75	26.55	11.20	44.29	5.82	—
September 18th	21	67.71	4.30	15.19	13.37	20.75	13.86	45.90	8.25	0.41

TABLE B.

Variety.	Date cutting.	Yield in grams dry.	Moisture.	Ether extract.	Crude Protein.	True Protein.	Fibre.	Ash.	Soluble carbo-hydrate	Silica. ($Si.\ O_2$).	Phosphoris Acid. ($P_2\ O_5$).
ANALYSIS OF HAY. 1922.											
Cocksfoot (U.S.A.)	12/6/22	496	62.25	2.90	6.12	5.34	34.02	4.51	52.45	1.51	—
Cocksfoot (Ind.)	,,	671	60.75	3.45	6.94	5.25	33.51	6.12	49.98	0.75	—
Per. Rye Grass (Danish) ..	16/6/22	320	62.60	2.90	5.31	4.00	26.55	4.75	60.49	1.25	—
Per. Rye Grass (Ind.) ..	,,	560	63.02	4.10	8.12	6.31	30.02	5.53	52.23	0.75	—
Timothy (U.S.A.)	14/7/22	361	64.02	2.35	5.94	5.12	26.08	3.65	61.98	0.92	—
Timothy (Ind.)	27/7/22	294	64.21	2.51	6.03	5.30	26.56	4.07	60.83	1.56	—
Tall Oat Grass (French) ..	21/6/22	289	59.77	2.80	6.06	4.81	28.75	3.14	59.23	0.93	—
Tall Oat Grass (Ind.) ..	4/7/22	232	64.28	3.65	8.00	6.81	27.57	5.13	55.65	1.42	—
Golden Oat Grass (Ind.) ..	29/6/22	357	62.86	3.00	9.12	7.12	29.72	4.44	53.72	1.15	—
Crested Dog's Tail (Ind.) ..	,,	147	70.18	3.25	6.25	5.00	29.00	4.72	56.78	1.75	—
R.S.M. Grass (Ind.)	21/8/22	159	49.82	4.00	6.81	5.75	25.85	6.55	56.79	2.85	—
Red Fescue (Ind.)	16/6/22	160	41.84	4.50	6.69	5.31	29.45	5.01	54.35	2.30	—
Meadow Fescue (Ind.) ..	10/7/22	293	67.01	1.40	6.62	5.37	32.61	5.32	54.05	1.33	—
Tall Fescue (Ind.)	,,	332	62.67	1.90	4.93	3.81	33.53	3.94	55.70	0.55	—
Meadow Foxtail (Ind.) ..	5/6/22	476	56.32	5.30	12.00	10.06	27.02	7.08	48.60	1.65	—
ANALYSIS OF HAY. 1923.											
Cocksfoot (U.S.A.)	21/6/23	179	70.52	1.80	7.75	5.81	37.75	4.51	48.19	1.53	0.46
Cocksfoot (Ind.)	,,	356	71.24	3.10	8.62	6.68	36.15	6.76	45.37	1.56	0.51
Per.Rye Grass (Danish) ..	22/6/23	391	68.21	2.57	5.81	5.18	33.52	4.92	53.18	1.01	0.46
Per. Rye Grass (Ind.) ..	,,	349	68.35	2.25	7.25	5.25	33.35	5.19	51.96	1.76	0.48
Timothy (U.S.A.)	25/7/23	201	64.50	2.25	7.06	5.43	32.10	3.93	54.66	0.86	0.42
Timothy (Ind.)	26/7/23	358	65.81	3.25	7.06	5.00	31.24	4.89	53.56	0.98	0.48
Tall Oat Grass (French) ..	22/6/23	135	68.15	2.10	7.62	5.54	31.75	6.13	52.40	2.13	0.60
Tall Oat Grass (Ind.) ..	15/7/23	158	69.41	3.35	8.81	6.90	30.25	6.13	51.46	1.41	0.55
Golden Oat Grass (Ind.) ..	,,	344	65.80	2.25	8.75	6.18	35.00	5.15	48.85	1.38	0.51
Crested Dog's Tail (Ind.) ..	5/7/23	297	66.72	1.85	5.00	4.18	34.50	4.33	54.32	1.51	0.44
Red Fescue (Ind.)	,,	437	62.83	2.25	8.50	6.56	40.51	3.98	44.76	1.33	0.40
Meadow Fescue (Ind.) ..	,,	310	70.02	1.55	7.87	5.65	35.50	6.42	48.66	1.69	0.60
Tall Fescue (Ind.)	,,	326	65.18	3.25	6.50	5.12	33.15	5.22	51.88	1.60	0.40
Meadow Foxtail (Ind.) ..	18/5/23	300	63.62	2.00	11.75	9.43	30.50	6.77	48.98	2.13	0.56

TABLE C.

Variety.	Date of cutting.	Yield in grams dry.	Mois-ture.	Ether extract.	Crude Protein.	True Protein.	Fibre.	Ash.	Soluble carbo-hydrate	Silica. (Si. O_2).	Phos-phoric Acid. (P_2O_5).
ANALYSIS OF AFTERMATH. 1922.											
Cocksfoot (U.S.A.)	21/9/22	161	72.14	4.45	11.75	8.75	32.15	8.30	43.35	3.40	—
Cocksfoot (Ind.)	,,	246	73.23	3.21	11.62	9.19	30.80	10.10	44.27	4.02	—
Per. Rye Grass (Danish) ..	,,	50	70.19	2.25	8.25	6.69	30.65	8.53	50.32	3.34	—
Per. Rye Grass (Ind.) ..	,,	108	75.30	4.25	10.19	7.12	22.35	9.11	54.20	4.21	—
Timothy (U.S.A.)	26/9/22	96	75.61	3.05	10.00	6.31	26.82	7.52	52.61	3.02	—
Timothy (Ind.)	,,	45	69.40	3.45	10.37	7.44	25.15	11.50	49.53	6.53	—
Tall Oat Grass (French) ..	29/8/22	124	71.80	2.55	8.44	7.19	30.82	5.53	52.66	1.56	—
Tall Oat Grass (Ind.) ..	26/9/22	137	72.32	3.10	12.06	7.94	28.44	9.61	46.79	3.62	—
Golden Oat Grass (Ind.) ..	,,	118	73.42	3.05	11.18	7.75	30.55	9.06	46.16	4.12	—
Crested Dog's Tail (Ind.) ..	,,	38	71.68	3.31	12.87	9.75	29.92	9.51	44.39	3.03	—
R.S.M. Grass (Ind.)	,,	39	73.55	2.42	10.31	7.81	19.75	12.70	53.82	6.81	—
Red Fescue (Ind.)	,,	78	70.93	2.95	9.56	7.12	28.52	10.70	48.27	6.22	—
Meadow Fescue (Ind.) ..	,,	130	75.18	3.00	11.77	7.19	28.22	10.00	46.01	4.00	—
Tall Fescue (Ind.)	,,	104	74.23	2.55	10.06	6.31	27.35	9.80	50.24	3.80	—
Meadow Foxtail (Ind.) ..	,,	231	72.81	3.00	10.81	7.75	29.70	8.53	47.93	4.52	—
ANALYSIS OF AFTERMATH. 1923.											
Cocksfoot (U.S.A.)	18/9/23	82	75.52	4.15	13.25	11.50	30.30	8.99	43.31	4.65	0.63
Cocksfoot (Ind.)	,,	194	76.87	4.70	12.81	11.06	30.95	10.86	40.68	6.72	0.81
Per. Rye Grass (Danish) ..	,,	130	74.50	4.15	11.58	9.43	25.55	8.32	50.40	4.23	0.64
Per. Rye Grass (Ind.) ..	,,	96	73.54	4.00	12.50	10.31	25.50	9.13	48.87	5.32	0.64
Timothy (U.S.A.)	,,	38	65.61	2.85	10.00	7.56	25.95	7.98	53.22	3.67	0.56
Ti mothy (Ind.)	,,	129	74.22	4.10	10.69	9.44	26.50	10.34	48.37	6.14	0.51
Tall Oat Grass (French) ..	,,	62	75.88	3.90	10.69	8.81	27.25	10.31	47.85	6.51	0.44
Tall Oat Grass (Ind.) ..	,,	72	73.15	4.35	18.19	13.62	26.45	11.34	39.67	6.85	0.65
Golden Oat Grass (Ind.) ..	,,	132	73.53	2.95	10.31	8.19	25.90	12.75	48.09	7.12	0.63
Crested Dog's Tail (Ind.) ..	,,	97	70.81	3.95	12.69	9.44	24.00	9.67	49.69	4.72	0.75
Red Fescue (Ind.)	,,	113	75.08	4.05	12.25	9.31	27.05	10.20	46.45	5.53	0.75
Meadow Fescue (Ind.) ..	,,	139	74.62	3.00	9.19	7.06	29.00	10.42	48.39	5.60	0.54
Tall Fescue (Ind.)	,,	136	73.26	3.05	9.50	7.19	28.50	8.70	50.25	4.03	0.66
Meadow Fosxtail (Ind.) ..	,,	272	73.16	3.00	10.12	7.06	31.60	8.44	46.84	4.92	0.44

TABLE D.

COCKSFOOT. Indigenous. (Bc. 605).

1922.

	19/4/22		9/5/22		30/5/22		20/6/22		11/7/22		1/8/22		22/8/22		13/9/22		30/9/22	
	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.
Ether Extract	2.20	5.25	5.75	5.80	3.67	4.55	2.67	5.05	* —	5.27	3.65	5.60	2.55	4.20	2.60	5.70	—	6.95
Crude Protein	14.16	25.09	20.58	31.61	17.70	35.19	15.05	25.50	18.25	27.51	17.56	27.13	16.28	26.44	20.38	26.89	—	29.87
Pure Protein	11.26	22.82	15.95	27.59	13.09	29.41	11.56	22.77	13.30	24.61	13.40	24.20	11.78	20.56	14.63	25.15	—	26.72
Fibre	19.70	18.30	25.80	17.80	31.32	17.32	34.67	20.12	—	19.40	32.65	20.85	35.60	24.55	32.95	20.00	—	18.77
Ash	7.14	7.38	8.51	9.19	8.20	10.62	8.73	11.07	—	11.64	4.94	11.46	9.42	10.59	12.90	14.72	15.38	17.31
Soluble Carbohydrates	56.80	43.98	39.36	35.60	39.11	32.32	38.88	38.26	—	36.18	41.20	34.96	36.15	34.22	31.17	32.69	—	27.10
Silica (SiO_2)	1.45	2.16	1.02	1.95	1.79	3.18	2.40	3.47	—	6.38	1.80	4.47	2.44	4.73	6.14	7.80	3.59	6.90
Phosphoric Acid (P_2O_5)	0.70	0.53	1.24	0.84	0.69	—	0.55	0.50	—	—	—	0.30	0.69	0.55	0.61	0.59	—	0.81

* Blanks imply, in this and subsequent tables, an insufficient amount of produce developed for the conduct of the necessary chemical analyses.

TABLE D.—*continued.*

COCKSFOOT. New Zealand. (Bc. 610).

1922.

	19/4/22		9/5/22		30/5/22		20/6/22		11/7/22		1/8/22		22/8/22		13/9/22		30/9/22	
	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.
Ether Extract	2.20	5.70	3.80	3.50	5.00	6.60	3.05	5.65	2.35	4.45	2.90	4.25	2.20	3.85	3.15	5.15	—	6.10
Crude Protein	13.14	23.06	20.66	30.83	16.59	32.54	17.19	30.06	17.15	25.25	14.92	24.61	15.00	24.50	16.81	24.50	—	29.19
True Protein	11.43	21.84	13.86	24.19	9.85	28.96	11.31	22.56	13.32	23.54	11.62	22.69	11.06	18.00	11.75	23.63	—	25.00
Fibre	19.90	17.65	25.40	18.80	31.47	16.92	31.70	19.60	28.75	21.85	31.90	22.60	31.95	23.90	29.35	23.95	—	26.00
Ash	6.39	7.57	9.08	8.93	9.05	11.55	7.12	10.52	9.75	11.42	10.33	12.03	9.20	11.17	13.33	12.65	13.43	13.30
Soluble Carbohydrates	58.37	46.02	41.06	37.94	37.89	32.39	40.94	34.17	42.00	37.03	39.95	36.51	41.65	36.58	37.36	33.75	—	25.41
Silica (SiO_2)	1.93	1.43	1.89	1.25	1.67	4.22	1.05	3.27	2.91	5.60	1.57	4.20	2.62	5.00	5.58	5.79	8.06	5.52
Phosphoric Acid (P_2O_5)	—	0.56	—	0.93	0.73	0.63	—	—	—	—	—	—	—	—	1.41	—	1.47	—

TABLE D.—*continued.*

COCKSFOOT. French. (Bc. 604).

1922.

	19/4/22		9/5/22		30/5/22		20/6/22		11/7/22		1/8/22		22/8/22		13/9/22		30/9/22	
	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.
Ether Extract	3.4	6.00	—	—	2.70	4.50	1.90	5.05	2.25	5.30	3.40	5.40	4.20	5.70	3.30	4.50	—	6.20
Crude Protein	13.0	22.19	18.73	30.37	16.89	32.93	13.90	25.50	15.21	27.18	16.38	29.55	16.00	26.63	15.50	27.31	—	31.93
Pure Protein	10.65	19.28	15.01	27.18	12.45	29.26	10.15	22.60	—	25.62	11.90	25.89	11.25	22.94	—	22.64	—	26.99
Fibre	18.60	13.90	—	—	31.90	16.70	38.05	22.45	29.90	16.40	34.50	18.30	35.00	24.25	32.90	18.65	—	18.90
Ash	—	5.12	—	—	4.22	—	6.62	13.34	—	11.10	—	8.99	8.24	8.78	10.24	13.09	16.15	14.96
Soluble Carbohydrates	—	52.79	—	—	44.29	—	39.53	33.66	—	40.02	—	37.76	36.56	34.64	38.06	36.45	—	28.01
Silica (SiO_2)	—	0.70	—	—	0.80	—	1.46	5.17	—	5.04	—	2.27	2.39	2.95	3.06	5.74	5.58	6.13
Phosphoric Acid (P_2O_5)	—	0.67	—	—	1.65	—	0.78	—	—	0.71	—	—	0.75	0.67	—	0.67	1.77	—

TABLE D.—*continued.*

COCKSFOOT. Danish. (Bc. 599).

1922.

	19/4/22		9/5/22		30/5/22		20/6/22		11/7/22		1/8/22		22/8/22		13/9/22		30/9/22	
	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.
Ether Extract	5.10	10.00	4.21	6.00	3.45	5.61	1.75	5.15	2.55	5.15	2.55	4.40	2.10	5.60	2.55	3.75	—	6.45
Crude Protein	15.30	24.75	19.62	30.63	17.15	33.69	12.53	26.70	16.97	27.89	16.93	29.37	14.13	26.56	15.56	25.31	20.38	31.84
True Protein	12.45	22.26	15.40	28.49	11.77	28.40	9.72	22.78	13.39	24.74	11.71	25.80	9.44	22.00	7.13	22.00	—	26.99
Fibre	18.70	16.20	27.93	18.30	32.55	21.20	44.05	21.00	31.35	19.30	32.60	20.50	35.10	25.00	28.50	22.35	—	19.85
Ash	—	7.65	8.33	8.01	8.69	11.28	7.31	9.73	9.88	10.99	9.50	9.88	8.72	9.80	11.17	12.69	19.58	14.14
Soluble Carbohydrates	—	41.40	39.91	37.06	38.16	28.22	34.36	37.42	39.25	36.67	38.42	35.85	39.95	33.04	42.22	35.90	—	27.72
Silica (SiO_2)	—	1.63	1.35	1.30	1.22	2.04	1.66	2.39	2.54	4.97	2.09	1.59	1.40	2.19	3.91	5.74	8.57	5.83
Phosphoric Acid (P_2O_5)	—	0.62	0.87	0.72	—	—	—	0.56	—	0.50	0.68	—	—	0.94	—	0.79	1.17	—

TABLE D.—*continued.*

COCKSFOOT. Swedish. (Bc. 905).

1922.

	19/4/22		9/5/22		30/5/22		20/6/22		11/7/22		1/8/22		22/8/22		13/9/22		30/9/22	
	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.
Ether Extract	—	4.50	—	5.81	3.30	5.22	2.25	5.10	2.70	4.80	2.35	4.90	3.60	4.85	3.55	6.25	—	4.85
Crude Protein	18.50	26.40	22.78	33.25	19.36	34.46	14.25	26.70	17.93	28.18	17.57	28.37	17.16	28.31	18.06	24.34	18.75	30.88
Pure Protein	—	23.20	18.08	29.68	13.31	30.54	10.32	23.12	16.73	25.71	12.99	25.80	11.50	21.88	11.56	22.33	—	27.06
Fibre	—	14.62	—	18.12	30.35	14.77	32.65	22.95	32.20	19.25	28.95	22.55	33.60	25.30	29.80	18.65	—	19.20
Ash	—	6.34	—	8.92	9.07	12.39	8.75	9.72	—	11.27	11.60	12.86	11.26	10.16	15.87	13.87	—	17.07
Soluble Carbohydrates	—	48.14	—	33.90	37.92	33.16	42.10	35.53	—	36.50	39.53	31.32	34.38	31.38	32.72	36.89	—	28.00
Silica (SiO_2)	—	1.15	—	0.92	1.58	2.61	1.86	2.43	—	5.06	2.50	2.82	2.91	2.16	6.52	9.10	—	7.86
Phosphoric Acid (P_2O_5)	—	—	—	0.58	0.47	—	0.69	0.49	—	0.66	—	—	0.87	1.15	—	—	—	0.92

TABLE E.

COCKSFOOT.—American. (Bc. 445).

1923.

	26/3/23			3/5/23		19/6/23		16/8/23		26/10/23	
	Stem.	Leaf.	Burn.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.
Ether Extract	3.75	4.65	3.05	2.45	3.64	3.80	5.10	1.70	3.35	—	3.85
Crude Protein	16.75	24.51	10.50	16.94	22.82	10.63	16.06	9.56	13.00	—	19.81
Pure Protein	11.32	19.25	9.00	12.00	16.85	8.44	13.64	7.06	9.56	—	16.94
Fibre	28.81	22.04	24.10	29.85	23.48	39.20	25.85	32.05	32.00	—	24.00
Ash	15.06	12.87	23.52	17.00	16.73	12.23	16.62	14.30	11.25	—	15.63
Soluble Carbohydrates ..	35.63	35.93	38.83	33.76	33.33	34.14	36.37	42.39	40.40	—	36.71
Silica (SiO_2)	3.29	3.62	17.96	5.56	6.52	2.80	8.93	6.86	5.52	—	8.09
Phosphoric Acid (P_2O_5) ..	0.89	0.75	0.57	1.05	1.06	0.67	0.87	0.82	0.66	—	0.69

TABLE E.—*continued.*

COCKSFOOT—French. (Bc. 456).

1923.

	26/3/23			3/5/23		19/6/23		16/8/23		26/10/23	
	Stem.	Leaf.	Burn.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.
Ether Extract	4.45	5.40	4.40	4.00	3.15	2.60	5.35	—	—	—	3.35
Crude Protein	18.00	25.00	11.94	17.19	22.85	9.88	14.69	—	—	—	18.43
Pure Protein	11.44	19.00	10.84	12.38	17.75	8.25	11.38	—	—	—	15.75
Fibre	26.50	23.75	28.57	30.02	22.85	38.85	31.30	—	—	—	22.70
Ash	14.52	10.52	24.66	14.70	17.27	13.45	15.27	—	—	—	15.44
Soluble Carbohydrates ..	36.53	35.33	30.43	34.09	33.88	35.22	33.39	—	—	—	40.08
Silica (SiO_2)	3.31	3.87	17.45	5.88	8.02	4.38	6.05	—	—	—	8.65
Phosphoric Acid (P_2O_5) ..	0.86	0.67	0.52	1.20	0.91	0.83	0.73	—	—	—	0.76

TABLE E.—*continued.*

COCKSFOOT.—Ayrshire (ex Danish). (Bc. 316).

	26/3/23			3/5/23		19/6/23		16/8/23		26/10/23	
	Stem.	Leaf.	Burn.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.
Ether Extract	3.80	4.35	2.00	3.85	3.50	2.90	4.00	1.45	4.70	—	4.10
Crude Protein	16.81	24.75	10.38	18.06	23.88	12.06	13.65	7.18	12.19	—	17.75
Pure Protein	11.50	19.40	9.00	12.73	19.31	8.68	13.02	6.25	8.63	—	15.75
Fibre	24.25	21.55	31.85	31.66	22.95	35.95	25.35	34.20	32.45	—	25.95
Ash	16.65	13.80	25.47	17.60	17.30	7.13	15.46	11.49	11.01	—	14.25
Soluble Carbohydrates ..	38.49	35.55	30.30	28.83	32.37	41.96	41.54	45.68	39.65	—	37.95
Silica (SiO_2)	3.15	3.90	19.02	3.99	7.70	2.33	7.35	4.84	5.21	—	6.98
Phosphoric Acid (P_2O_5) ..	1.00	0.64	0.58	1.12	0.89	0.65	0.92	0.61	0.92	—	0.75

TABLE E.—*continued.*

COCKSFOOT—Indigenous. (Bc. 551).

1923.

	26/3/23			3/5/23		19/6/23		16/8/23		26/10/23	
	Stem.	Leaf.	Burn.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.
Ether Extract	5.21	5.85	2.53	3.20	—	3.10	4.60	2.55	4.00	—	3.60
Crude Protein	15.19	24.69	9.93	18.75	—	10.69	10.94	9.96	14.94	—	18.06
Pure Protein	11.50	19.25	8.38	13.56	—	6.11	8.19	7.63	11.63	—	15.32
Fibre	26.64	22.95	25.05	28.01	—	41.75	28.15	33.70	29.55	—	22.66
Ash	16.02	13.54	23.70	15.38	—	7.38	16.00	13.40	12.25	—	14.73
Soluble Carbohydrates	36.94	32.97	38.79	34.66	—	37.08	40.31	40.39	39.26	—	40.95
Silica (SiO_2)	3.48	3.96	16.70	3.56	—	2.11	8.74	4.85	5.32	—	8.07
Phosphoric Acid (P_2O_5)	0.84	0.69	0.39	1.05	—	0.66	0.84	1.00	0.72	—	0.72

TABLE E.—*continued.*

COCKSFOOT—Indigenous. (Bc. 537).

1923.

	26/3/23			3/5/23		19/6/23		16/8/23		26/10/23	
	Stem.	Leat.	Burn.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.
Ether Extract	5.10	5.75	2.60	3.61	4.25	1.90	3.65	2.60	3.50	—	4.75
Crude Protein	15.00	24.00	10.94	17.99	23.33	8.94	11.06	9.13	12.78	—	18.44
Pure Protein	11.25	18.88	9.38	12.50	19.65	5.19	8.50	6.69	10.81	—	15.78
Fibre	27.65	26.77	26.15	30.27	23.25	43.50	28.60	34.55	31.50	—	25.75
Ash	14.82	12.63	22.36	15.52	17.46	11.64	12.83	11.92	11.78	—	15.21
Soluble Carbohydrates ..	37.43	30.85	37.95	32.61	31.71	34.02	43.86	41.80	40.44	—	35.85
Silica (SiO_2)	3.35	3.87	15.02	3.68	6.55	3.00	6.08	4.46	4.97	—	7.97
Phosphoric Acid (P_2O_5) ..	0.93	0.60	0.41	0.93	0.80	0.68	0.91	0.80	0.80	—	0.92

TABLE E.—*continued.*

COCKSFOOT—Indigenous. (Bc. 284).

1923.

	26/3/23			3/5/23		19/6/23		16/8/23		26/10/23	
	Stem.	Leaf.	Burn.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.
Ether Extract	3.20	3.80	2.95	3.60	3.85	1.85	4.00	1.65	4.40	—	3.75
Crude Protein	17.38	26.81	11.75	17.62	23.56	9.38	13.44	7.88	15.06	—	17.63
Pure Protein	11.95	19.06	9.40	12.50	20.25	6.69	13.13	7.00	12.94	—	15.44
Fibre	26.15	21.50	28.70	30.18	23.60	40.35	24.30	34.40	29.65	—	24.05
Ash	14.41	12.84	25.17	16.34	16.41	7.46	14.45	11.81	11.50	—	14.74
Soluble Carbohydrates ..	38.86	35.05	31.43	32.26	32.58	40.96	43.81	44.26	39.39	—	39.83
Silica (SiO_2)	3.40	3.06	19.55	3.96	7.44	1.78	7.08	4.38	4.90	—	7.69
Phosphoric Acid (P_2O_5) ..	0.91	0.68	0.49	1.01	0.91	0.70	1.10	1.05	—	—	0.73

TABLE F.

PERENNIAL RYE GRASS—Commercial. (Ba. 211).

1923.

	27/6/23		27/7/23		30/8/23		4/10/23	
	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.
Ether Extract	1.25	2.50	2.45	2.45	3.80	5.90	—	6.05
Crude Protein	13.00	24.81	15.50	24.75	13.62	21.87	—	25.06
Pure Protein	11.50	19.81	11.31	20.37	10.31	18.75	—	20.06
Fibre	31.50	20.80	26.85	19.73	26.80	24.78	—	19.40
Ash	8.10	11.24	8.87	11.58	8.47	12.69	—	11.56
Soluble Carbohydrates	46.15	40.65	46.33	41.49	47.31	34.76	—	37.93
Silica (SiO_2)	1.53	2.88	3.78	4.72	3.66	5.46	—	6.01
Phosphoric Acid (P_2O_5)	0.72	0.55	1.00	0.78	0.92	0.55	—	0.71

TABLE F.—*continued.*

PERENNIAL RYE GRASS—Indigenous. (Ba. 175).

1923.

	27/6/23		27/7/23		30/8/23		4/10/23	
	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.
Ether Extract	1.45	2.05	3.30	3.65	3.10	3.35	—	5.05
Crude Protein	11.68	18.87	10.37	17.68	11.56	18.75	—	22.75
Pure Protein	9.37	15.18	8.75	13.68	—	14.56	—	16.75
Fibre	30.20	24.20	28.60	20.15	23.80	21.60	—	24.65
Ash	6.55	9.00	9.86	11.50	—	13.50	—	13.01
Soluble Carbohydrates	50.12	45.88	47.87	47.02	—	42.80	—	34.54
Silica (SiO_2)	1.34	1.60	4.76	5.55	—	6.36	—	5.11
Phosphoric Acid (P_2O_5)	1.01	0.62	0.91	0.65	—	0.56	—	0.68

TABLE F.—*continued.*

PERENNIAL RYE GRASS—Indigenous. (Ba. 198).

1923.

	27/6/23		27/7/23		30/8/23		4/10/23	
	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.
Ether Extract	2.10	3.45	2.85	4.70	3.35	3.70	—	5.30
Crude Protein	11.56	19.00	15.62	22.12	10.87	18.75	—	23.31
Pure Protein	8.31	15.81	11.56	16.31	—	15.81	—	18.00
Fibre	26.40	21.40	28.73	20.50	—	22.85	—	21.25
Ash	5.87	11.10	9.33	11.20	—	12.39	—	11.60
Soluble Carbohydrates	54.07	45.05	43.47	41.48	—	42.31	—	38.54
Silica (SiO_2)	2.77	2.66	3.43	3.27	3.10	4.70	—	4.78
Phosphoric Acid (P_2O_5)	0.72	0.70	0.98	0.66	0.62	0.46	—	0.66

TABLE F.—*continued.*

PERENNIAL RYE GRASS—Indigenous. (Ba. 199).

1923.

	27/6/23		27/7/23		30/8/23		4/10/23	
	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.
Ether Extract	2.40	3.50	2.65	4.25	—	3.75	—	6.10
Crude Protein	15.46	22.50	12.31	20.47	—	21.31	—	25.25
Pure Protein	9.43	14.75	9.62	15.75	—	14.68	—	19.06
Fibre	24.20	24.55	29.30	21.30	—	23.45	—	21.50
Ash	6.54	8.77	5.66	9.89	8.72	11.71	—	10.22
Soluble Carbohydrates	51.40	40.68	50.08	44.09	—	39.78	—	36.93
Silica (SiO_2)	1.06	1.60	2.77	2.54	3.45	4.07	—	3.00
Phosphoric Acid (P_2O_5)	0.86	0.64	0.83	0.59	0.72	0.59	—	0.74

TABLE F.—*continued.*

TIMOTHY—Indigenous. (Ck. 5).

1923.

	13/7/23		16/8/23		17/8/23	
	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.
Ether Extract	2.00	3.75	3.22	3.95	2.70	3.00
Crude Protein	10.00	10.18	10.25	19.56	9.62	18.25
Pure Protein	7.37	13.87	8.87	15.31	7.25	12.18
Fibre	39.00	24.75	32.15	25.30	25.32	23.60
Ash	8.00	13.21	8.19	11.70	8.02	10.65
Soluble Carbohydrates	41.00	48.11	46.19	39.49	54.34	44.50
Silica (SiO_2)	1.42	2.51	2.63	3.01	2.61	4.22
Phosphoric Acid (P_2O_5)	0.85	0.50	0.75	0.47	0.76	0.55

TABLE F.—*continued.*

TIMOTHY—Indigenous. (Bd. 97).

1923.

	13/7/23		16/8/23		17/9/23	
	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.
Ether Extract	1.95	4.50	3.10	3.60	3.21	3.60
Crude Protein	10.87	20.62	10.12	21.86	16.62	26.25
Pure Protein	8.93	18.87	9.37	13.56	10.50	20.81
Fibre	34.25	25.00	31.54	25.35	25.47	23.75
Ash	9.22	12.60	8.25	11.08	8.91	10.31
Soluble Carbohydrates	43.71	37.28	46.99	38.11	45.79	36.09
Silica (SiO_2)	1.95	2.77	3.01	3.77	2.96	4.46
Phosphoric Acid (P_2O_5)	0.66	0.58	0.76	0.64	1.03	0.54

TABLE F.—*continued.*

TIMOTHY—Indigenous. (Bd. 124).

1923.

	13/7/23		16/8/23		17/9/23	
	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.
Ether Extract	2.50	5.00	2.61	3.05	3.08	3.30
Crude Protein	12.43	24.81	11.37	23.81	17.00	27.00
Pure Protein	8.25	20.37	7.32	22.37	12.50	24.37
Fibre	37.50	24.25	31.66	24.00	23.42	22.10
Ash	6.00	13.24	8.03	9.95	8.12	9.01
Soluble Carbohydrates	41.57	32.70	46.33	39.19	48.38	38.59
Silica (SiO_2)	1.18	4.12	2.24	2.84	2.57	3.45
Phosphoric Acid (P_2O_5)	0.75	0.50	0.68	0.51	0.87	0.56

TABLE F.—*continued.*

TIMOTHY—Indigenous. (Bd. 95).

1923.

	13/7/23		16/8/23		17/9/23	
	Stem.	Leaf.	Stem.	Leaf.	Stem.	Leaf.
Ether Extract	2.75	5.05	1.50	3.45	3.55	4.00
Crude Protein	13.25	23.43	12.68	20.81	16.87	26.43
Pure Protein	9.62	20.50	11.37	13.06	12.04	23.43
Fibre	34.50	24.25	31.80	25.86	26.42	25.10
Ash	6.00	8.08	7.58	11.48	7.31	7.74
Soluble Carbohydrates	43.50	39.19	46.44	38.40	45.85	36.73
Silica (SiO_2)	1.15	2.63	2.50	3.04	2.05	2.61
Phosphoric Acid (P_2O_5)	0.77	0.45	0.68	0.53	1.08	0.57

The Productivity of different Strains and Nationalities of Red Clover under Hay and Pasture Conditions (represented by eight monthly pasture cuts).

by

R. D. WILLIAMS, B.Sc.

This experiment (A. 49) was carried out on moderately light but fairly even soil in The Lower Ridge Field. Some thirty-one lots of seeds, representing fourteen strains and nationalities of red clover were sown in May, 1922, in duplicated 20 feet drills at 30 inches apart. All the lots were sown at the uniform rate of 1000 viable seeds per drill. By constant hoeing the ground was kept free of weeds.

All the lots made such rapid growth during the seeding year that they were cut as hay on the 13th October, 1922. In order to obtain as direct a comparison as possible of the behaviour of the different strains under hay and pasture conditions, each drill was divided into two equal lengths of ten feet each, one portion was kept for hay from October, 1922, and the other allocated for pasture cutting.*

The hay drills were cut when in full bloom, or as near to the full bloom stage as the weather permitted.

The dates of full bloom of the different strains and nationalities are given below :—

Wild Strains.		*Intermediate Strains.*	
Wild Red.	6th July.	Vale of Clwyd.	23rd July.
Early Strains.		*Late Strains.*	
American Medium.	5th ,,	English Late.	20—24th July.
English Broad Red.	14—18th July.	Swedish Late.	26—28th ,,
Bohemian.	16th ,,	Cornish Marl.	28th ,,
Chilian.	17th ,,	Montgomeryshire.	30th ,,
Brittany.	17th ,,	American Mammoth	3rd August.

Thus Wild Red and American Medium were about 8 to 11 days earlier than the other early strains, and about 14 to 24 days earlier than the late strains.

Owing to the very wet late summer and autumn the aftermaths were not weighed. As the clover had made but very little growth during August and September on account of the cold wet weather, the aftermath yields were almost negligible, as shown by the fact that the percentage weights of aftermath

* Used in the same sense as in previous articles.

to hay yields given by Montgomeryshire and English Broad Red in another experiment on an adjoining area were only 3.4 and 6.5 per cent. respectively.

In order to determine the ratios of stem to leaves, and the percentage dry matter in each strain, representative samples of 500 grams were taken from the green hay of each lot immediately after cutting. These samples were then separated into stem and leaves—all petioles, stipules and flower heads, as well as the leaflets, were classified as leaves—and then air dried and afterwards oven dried for 3 days at a temperature of 90 °c—98 °c to determine the percentage dry matter.

The pasture drills were cut on a four weekly schedule, the first cut being made on the 5th March, 1923, and the last on 26th September, making a total of eight cuts. The weights obtained from the 1st cut represented the growth for the period 13th October, 1922, to 5th March, 1923, that is, 133 days. The cutting was performed by means of shears at about half an inch from the ground. The percentage dry matter and the ratios of stem to leaves were each determined on separate 100 gram samples—the samples being weighed immediately after cutting. Each of the eight cuttings were made when the drills were quite dry, and to ensure this the cuttings had to be delayed on three occasions and so slightly departed from the strict schedule dates.

HAY YIELDS. It is obvious, since the yields were obtained on short cultivated drills, that the actual weights are of no practical significance. That the yields given by drills may serve as a general indication of the relative values of the main groups—namely, the late flowering, early flowering and wild red clover—has been shown by comparison with the results obtained under normal field conditions.

TABLE I.—*To show the average yields as hay and pasture, expressed in terms of green weights, dry weights and weights of leaves and flower heads, of different nationalities of Red Clover during the first harvest year,* 1923.

The yields are expressed as grams per 10 foot drills.

	Hay.			Sum of Pasture Cuts.		
	Green fodder.	Dry fodder.	Dry leaves and fl. hds.	Green fodder.	Dry fodder.	Dry leaves and fl. hds.
English Late flowering	5740.8	1190.7	453.1	1488.1	232.4	198.6
Montgomeryshire Late	5911.0	1119.8	447.2	2243.2	338.4	302.6
Cornish Late	7039.3	1342.3	523.3	2221.8	329.2	272.0
Swedish Late ..	8269.6	1468.5	592.5	2525.2	350.6	312.2
Amer. Mammoth ..	7521.2	1487.3	551.7	1791.3	271.0	230.3
Clwyd	5026.4	993.7	451.3	2399.3	352.1	289.1
English Broad Red ..	4065.4	703.2	386.1	1730.1	262.7	219.2
Brittany	3881.1	666.3	374.5	1248.1	196.2	162.6
Chilian	3878.3	666.3	335.7	906.3	148.7	123.0
Bohemian	4589.8	764.5	365.4	1969.4	286.3	236.9
Amer. Medium ..	3988.8	734.4	402.6	1822.5	281.5	238.2
Italian	1652.8	274.9	144.8	298.3	49.6	42.0
Wild	3988.8	844.8	427.2	1525.1	259.3	199.8

Table I. (column 1) which gives the average weights of green hay produced by the different nationalities, shows that all the "late" strains have out-

TABLE II.—*To show the average yields of dry fodder and dry leaves and flower heads given by Wild Red, Late and Early strains.*

Grams per 10 foot drills.

	No. of Strains.	Hay.		Sum of pasture cuts.	
		Dry fodder.	Leaves & fl. hds.	Dry fodder.	Leaves & fl. hds.
Late Strains	5	1321.7	513.6	304.6	263.1
Early Strains	5	706.9	372.9	235 1	196.0
Wild	1	844.8	427.2	259.3	199.8

The strains included in the above table are :—

Lates :—English, Montgomeryshire, Cornish, Swedish, and American Mammoth.

Earlies :—English, Brittany, Chilian, Bohemian, and American Medium.

As the yields obtained from Italian Red were so low they were not included.

yielded the " earlies " by a very considerable margin, and as shown in Table II., which is a summary of the results in Table I., the weights of dry fodder yielded by five earlies was only 61 per cent. of that yielded by a similar number of late strains. Even the Wild Red gave a slightly heavier yield of dry fodder than the average for the earlies.

The great superiority of the lates over the earlies for the production of hay is still more clearly demonstrated in Table III. (column 1), which shows that while the relative yields of green fodder of the late strains ranged from 100 to 143.9, the relative yields of the earlies were only 28.8 to 79.9.

TABLE III.—*To show the relative yields of* (a) *green fodder,* (b) *dry fodder, and* (c) *dry leaves and flower heads in the Hay and Pasture given by different strains of Red Clover in the first harvest year.*

All the weights are expressed in terms of the yields of English Late Flowering Red = 100.

	Hay.			Sum of Pasture Cuts.		
	Total green fodder.	Total dry fodder.	Dry Leaves & flower hds.	Total green fodder.	Total dry fodder.	Dry Leaves & flower hds.
English Late Flrg.	100.0	100.0	100.0	100.0	100.0	100.0
Montgomeryshire Lt.	102.9	94.0	99.0	151.0	145.5	151.7
Cornish Late ..	122.7	112.8	115.4	149.5	141.5	136.4
Swedish Late ..	143.9	123.2	131.0	170.0	150.7	156.5
Amer. Mammoth ..	130.8	124.8	121.8	120.5	116.4	115.4
Clwyd	87.5	84.0	99.7	161.1	151.1	140.0
English Broad Red	71.0	59.1	85.4	116.2	112.9	109.9
Brittany	67.5	56.0	82.8	83.0	88.4	81.6
Chilian	67.5	56.0	74.1	60.9	63.0	61.7
Bohemian	79.9	64.2	80.7	125.6	123.0	119.0
Amer. Medium ..	69.5	61.8	89.0	122.6	121.0	119.4
Italian	28.8	23.6	32.1	20.0	21.3	21.2
Wild	69.5	71.0	94.4	102.5	111.3	100.1

There seems to be no doubt that the cold spell which occurred about the middle of May was very largely responsible for the unusually poor yields of the early strains, as it was observed at the time that all these strains were more or less badly injured by the light frosts while the lates were hardly affected.

TABLE IV.—*To show* (a) *percentage dry matter,* (b) *percentage leaves and flower heads in the "Hay" and "Pasture" cuts, and the percentage leaves to stem and leaves* (*i.e., excluding the flower heads*).

		Percentage dry matter.		Percentage Leaves and fl. hds. to total dry matter.		Dry wt. Percentage Leaves to weight of stem and leaves.
		Hay.	Pasture.	Hay.	Pasture.	Hay.
English Late Flrg.	3	20.78	15.70	38.2	86.7	26.8
Montgomeryshire Lt.	1	19.36	15.50	42.2	89.5	34.4
Cornish Late ..	2	19.08	14.90	38.9	82.2	30.1
Swedish Late ..	2	17.76	13.90	40.4	89.1	32.3
Amer. Mammoth ..	2	19.64	15.15	37.1	85.0	31.2
Clwyd	2	19.76	14.70	45.2	82.1	35.6
English Broad Red	6	17.14	15.20	55.6	83.5	50.9
Brittany	2	17.19	15.40	55.6	85.0	51.6
Chilian	2	17.22	16.45	50.3	82.6	45.0
Bohemian	2	16.71	14.55	47.8	82.8	41.8
Amer. Medium ..	2	18.42	15.20	55.0	86.2	48.2
Italian	1	16.65	16.70	52.7	84.7	45.0
Wild	2	21.17	17.00	50.7	77.3	38.7

The yields of the total dry matter and of the dry leaves and flower heads of the "Pasture" cuts were arrived at by totalling up the calculated dry matter of each of the eight cuttings.

DRY MATTER IN HAY. As will be seen from the average percentage dry matter in green hay given in Table IV. (column 1) the dry matter contents of different strains vary considerably. The Wild Red lots which contained on the average as much as 21.17 per cent. dry matter, gave consistently higher results than any of the commercial lots. With the exception of Swedish late, all the late strains had a higher percentage dry matter than any of the earlies, and as shown in Table V. the five strains of "lates" and the six strains of "earlies" had on the average 19.62 per cent. and 17.24 per cent. dry matter respectively. Of the early flowering clovers the highest results were given by American Medium with 18.42 per cent., and the lowest by Italian and Bohemian with 16.65 and 16.71 dry matter respectively. English, Brittany and Chilian Reds had fairly similar dry weight contents. The Vale of Clwyd clover, which on morphological grounds to be discussed on a future occasion, would appear to have originated as a result of natural crossing between early flowering and late strains, resembles the lates very closely in its dry matter content.

LEAFINESS OF HAY. As may be seen from a glance at the results given in Table IV. (column 3), the hay yielded by the early flowering strains was much more leafy than that produced by the late strains. The hay given by the

TABLE V.—*To show the average percentage dry matter, leaves and flower heads in the Hay and Pasture cuts of Wild, Late and Early Flowering strains.*

(= Summary of Table III.).

	No. of Strains.	Percentage dry matter.		Percentage leaves and fl. hds. to total dry matter.	
		Hay.	Pasture.	Hay.	Pasture.
Late strains	5	19.62	15.2	39.36	86.51
Early strains	6	17.24	15.6	52.84	84.16
Wild	1	21.17	17.0	50.70	77.35

The strains included in the above table are :—

Lates :—English Late Flowering, Montgomeryshire, Cornish, Swedish and American Mammoth.

Earlies :—English, Brittany, Chilian, Bohemian, American Medium and Italian.

early strains had from 47.85 to 55.6 per cent. leaves and flower heads, while that of the late strains had only 37.1 to 42.2 per cent. If the flower heads are excluded from the ratios the differences in leafiness between the groups are still further accentuated as shown in Table IV. (column 5). The Wild Red and the Vale of Clwyd held an intermediate position between the two commercial groups in respect to leafiness.

The superiority of the early over the late strains in leafiness is probably largely accounted for by the greater amount of secondary growth that occurs in the former during July and August. By the time the early strains are ready for hay an appreciable amount of basal growth has usually taken place, which springs up in the form of aftermath as soon as the hay is removed. The late strains, on the contrary, make practically no preparation for aftermath growth until the plants are well past the full bloom stage.

In another experiment the secondary growth of three lots each of English Broad Red, English Late Flowering and Montgomeryshire Late, cut when in full bloom was separated out. The weights of air dried secondary growth, which consisted almost entirely of leaves in 100 lb. of air dried hay, are given below :—

	lb.
English Broad Red	14.95
English Late Flowering	2.58
Montgomeryshire	3.79

Thus the English Early Red had about six times as much basal leaves as the English late, and four times as much as the Montgomeryshire late.

DEVELOPMENT OF FLOWER HEADS IN HAY. The figures given in Table VI. are interesting in this connection. The wild red gave nearly twice the number of flower heads per 1000 grams (green weight) as any commercial strain. The two foreign late strains flowered rather poorly in comparison with the three indigenous late strains, which, on the other hand, produced more flower heads per unit weight than most of the early flowering strains. When the high yielding capabilities of the late strains are taken into consideration, it is evident that they produce about twice the number of flower heads per unit area as the early strains.

TABLE VI.—*To show the average number of flower heads (open and in bud) in the Hay, and in July and August pasture cuts.*

Per 1000 grams.

Strain or Nationality.	Hay. No. of heads.	Pasture cuts. 26th July. No. of heads.	Pasture cuts. 24th August. No. of heads.
English Late	357	430	510
Montgomeryshire Late	352	180	250
Cornish Late	342	460	600
Swedish Late	238	150	110
American Mammoth	247	60	80
Vale of Clwyd	336	480	440
English Broad Red	294	470	400
Brittany	262	340	500
Chilian	362	380	280
Bohemian	225	400	310
American Medium..	286	210	270
Italian	304	510	230
Wild	684	1560	1010

PASTURE CUTS. PRODUCTIVITY OF THE DIFFERENT STRAINS UNDER PASTURE CONDITIONS. By reference to Table I., which gives the total pasture yields, and Table III., which shows the relative yields of each strain, it will be seen that the strains responded very differently under cutting conditions. The difference between the three most productive late strains—Swedish, Cornish and Montgomeryshire, and the intermediate strain—the Vale of Clwyd—on the one hand and the Italian or even Chilian and Brittany, on the other hand, is enormous. English late flowering gave rather poor results as compared with the other two indigenous strains of lates. American Mammoth gave about similar yields to the best early strains, namely, English, American Medium and Bohemian.

Speaking generally the late strains were able to withstand pasture conditions better than the earlies even in the first harvest year. As may be seen from Table II., the five late strains gave on the average 30 per cent., and the Wild Red only 8.4 per cent. more fodder than five early strains (Italian excluded) when cut eight times during the growing season.

These results are in full agreement with those obtained from a similar experiment conducted in 1922 in which the average aggregate pasture yield of the early strains was only 78 per cent. of that given by the late strains.

It is worthy of note that Bohemian, which in certain respects serves as a kind of connecting link between the late and early strains was the most productive of the latter group, and that the Vale of Clwyd, which as previously suggested, is probably a late x early hybrid, produced far heavier yields than any of the early strains proper. These facts are of special significance, as they suggest that the greater productivity of these two strains under grazing conditions may be the direct result of inter-crossing between the late and early strains.

PERIODICAL PRODUCTIVITY UNDER CUTTING CONDITIONS. The weights of green fodder obtained at each of the 8 pasture cuts are given in

TABLE VII.—*To show the average weights of green fodder, in grams per* 10 *feet drills, given by each of the eight monthly pasture cuts made on different strains and nationalities of Red Clover during the* 1*st harvest year,* 1923.

Nationality.	No. of lots.	Mar. 5	Apr. 2	May 2	May 30	June 27	July 26	Aug. 24	Sep. 26	Sum of cuts.
English Late Flowering	3	89.7	88.7	130.5	155.2	288.9	434.5	215.8	84.5	1487.8
Montgomeryshire Late	1	79.0	101.2	183.5	307.0	652.0	632.0	203.5	85.0	2243.2
Cornish Late	2	70.8	85.2	248.5	297.9	538.3	696.5	204.3	80.3	2221.8
Swedish Late	2	126.3	138.5	299.5	185.8	640.8	594.8	423.0	116.5	2525.2
American Mammoth	2	50.8	77.2	171.0	176.0	487.0	471.3	284.8	73.4	1791.5
Clwyd	2	136.3	120.9	157.5	220.0	551.8	838.5	271.3	103.0	2399.3
English Broad Red	6	118.8	101.0	104.3	139.3	361.1	556.8	251.2	97.7	1730.1
Brittany	2	121.0	99.7	99.3	93.2	190.2	356.0	223.5	65.2	1248.1
Chilian	2	86.8	47.0	56.5	54.0	175.3	257.3	176.0	53.0	905.9
Bohemian	2	141.5	136.4	123.0	129.0	346.5	685.0	320.3	92.8	1974.5
American Medium	2	90.5	104.7	155.5	107.5	354.0	506.8	355.0	148.8	1822.3
Italian	1	23.0	25.3	18.5	11.0	39.5	103.0	53.5	24.5	298.3
Wild	2	27.8	97.7	130.8	158.3	414.3	461.7	180.0	74.8	1545.4

TABLE VIII.—*To show the average percentage weight of green fodder to total green yield given at each pasture cut.*

Nationality.	No. of lots.	Mar. 5.	April 2.	May 2.	May 30.	June 27.	July 26.	Aug. 24.	Sept. 26.
English Late Flowering ..	3	6.1	6.0	9.1	10.3	19.2	29.2	14.5	5.6
Montgomeryshire Late.. ..	1	3.5	4.5	8.2	13.6	29.2	28.2	9.1	3.8
Cornish Late	2	3.2	3.7	11.2	13.4	24.3	31.1	9.2	3.7
Swedish Late	2	5.0	5.5	11.8	7.5	25.4	23.5	16.7	4.6
American Mammoth	2	2.8	4.3	9.5	9.9	27.2	26.3	15.9	4.1
Clwyd	2	5.7	5.0	6.6	9.2	23.0	34.9	11.3	4.3
English Broad Red	6	6.8	5.9	6.1	8.0	20.8	32.1	14.5	5.7
Brittany	2	9.6	8.1	8.1	7.4	15.2	28.5	17.9	5.2
Chilian	2	9.6	5.2	6.2	6.0	19.2	28.6	19.4	5.7
Bohemian	2	7.2	6.8	6.3	6.5	17.5	34.8	16.3	4.6
American Medium	2	4.9	5.7	8.5	5.9	19.4	27.8	19.5	8.3
Italian	1	7.7	8.5	6.2	3.7	13.3	34.5	17.9	8.2
Wild	2	1.8	6.3	8.4	10.3	26.7	29.9	11.7	4.9

Table VII. As already explained the first cut represents the total growth made during the winter period extending from 13th October, 1922, to 5th March, 1923. Now if the weights given by the early and late strains for this period are compared, it will be found that the late strains gave on the average only 71.5 per cent. of the keep afforded by the early strains during the dead season (if the abnormally high yields of Swedish late are excluded). Again, during March, as shown by the cut on April 2nd, the early strains gave on the average slightly more keep than the lates. But, during April the early strains were easily surpassed by the lates, and this advantage, which was increased during May, was still further accentuated during June, when most of the late strains reached their growth zenith. None of the early strains, on the other hand, reached their zenith until July, when the late strains were exhibiting distinct signs of falling off, although they were still on about a par with the early strains in yield. During August, the late strains were excelled by those earlies which were best able to withstand severe cutting, namely, English, Bohemian and American, and the advantage in favour of these early strains was maintained to the end of September. The Wild Red behaved in the main fairly similarly to the late strains, except that its winter growth, which was almost as poor as that of Italian, was practically negligible.

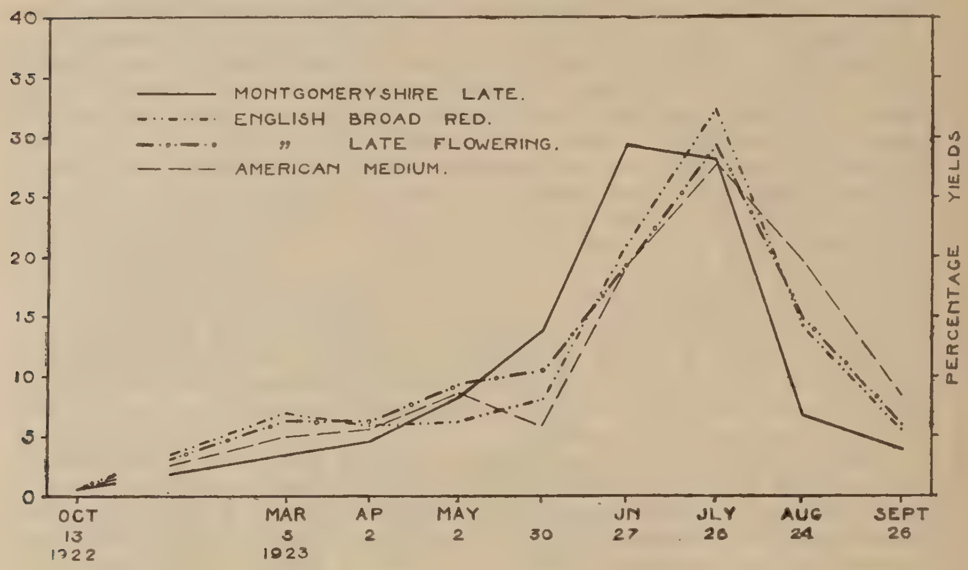
The reaction of the different strains to the cold spell which occurred about the middle of May is well reflected in the yields given on 30th May. Montgomeryshire and Cornish lates and the Vale of Clwyd strain gave a substantial increase over the cut made on May 2nd ; English late, English early and Wild Red a moderately good increase ; while the only foreign clovers which showed any increase at all, and that was very small, were American Mammoth and Bohemian. These results, which confirm the observations made on the appearances of the plots at the time, prove fairly conclusively that the British strains of Red Clover, more especially the late strains, are capable of showing a greater degree of resistance to frost occurring during active growth, than other strains under test.

It will be seen from a glance at Table VIII., which shows the percentage contribution of each cut to the total pasture yield of each strain, that, with the exception of a few relapses during May, there was a very gradual increase in growth during March, April and May. During June and July the rate of growth was very rapid—but in August the dropping off of the weights was very pronounced, and by the end of September the April level was again reached. This periodicity is illustrated in Figure I. As shown in Table VIII. as much as 48.4 to 57.4 per cent. of the whole of the 12 months' pasture produce was developed during June and July.

DRY MATTER IN PASTURE CUTS. As will be seen from the results given in Table IV. (column 2), which shows the percentage of dry matter in the sum of the pasture cuts, there were fairly wide differences between the different strains in respect of the percentage dry matter ; for example, Wild Red contained as much as 17 per cent., while the Swedish late had only 13.9 per cent. dry matter.

Perhaps with the single exception of Wild Red, it is extremely doubtful if the differences can be regarded as characteristic of the various strains. On the contrary, there are strong reasons for believing that the rates and amounts of growth have a profound influence on the water content of the pasture cuts. If the aggregate green weight of the pasture cuts in Table VII. are compared

FIGURE I.—*To show the yields given by each of eight monthly cuts, in percentage of total yield (green fodder) for four nationalities and strains of Red Clover.*



with their corresponding percentage of dry matter given in Table IV. (column 2) it will be found that the heavy yielding strains invariably contained the lowest percentage of dry matter, and *vice versa*, thus :—

	Aggregate green weight of pasture. Grams per 10 feet.	Percentage dry matter in aggregate yield.
Swedish Late	2525.2	13.9
Vale of Clwyd	2399.3	14.7
Cornish Late	2221.8	14.9
Bohemian	1974.8	14.5
English Late	1487.8	15.7
Chilian	905.8	16.4
Italian	298.3	16.7

Still more light will be thrown on this interesting problem if the green weights of each cut shown in Table VII. are compared with their corresponding percentage of dry matter given in Table IX. As illustrated in Figure II., the percentage dry matter decreased more or less rapidly as the green weight increased. until a critical percentage dry matter was reached when the decrease became very gradual in spite of the rapid acceleration in the rate of growth ; thus in Montgomeryshire late an increase in the green weight of the pasture cuts from 39 to 307 grams was accompanied by a proportional decrease in percentage dry matter from 22.6 to 13.8—which may be regarded as the critical dry matter point for this strain. Although the green weight decreased rapidly to 652 grams and then dropped slightly to 632 grams. the percentage dry matter at first actually increased and then showed a slight drop to 12.6.

TABLE IX.—*To show the percentage dry matter in different nationalities of Red Clover in each of eight monthly cuts, March 5th—September 26th.*

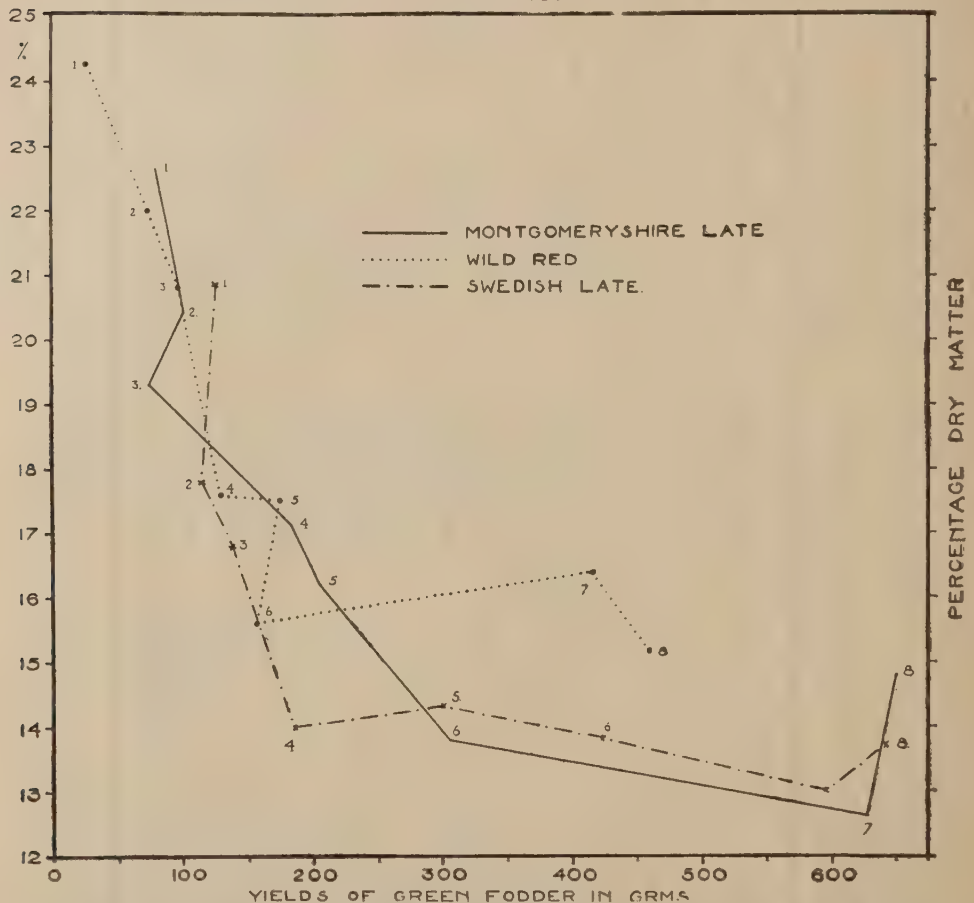
Nationality.	No. of lots.	Mar. 5.	April 2.	May 2.	May 30	June 27.	July 26.	Aug. 24.	Sept. 26.
English Late Flowering ..	3	21.2	18.3	16.1	15.4	15.4	13.5	15.6	18.5
Montgomeryshire Late.. ..	1	22.6	20.4	17.1	13.8	14.8	12.6	16.2	19.3
Cornish Late	2	23.0	19.8	15.4	13.8	14.7	13.1	15.9	19.3
Swedish Late	2	20.8	16.8	14.4	14.0	13.7	12.0	14.3	17.7
American Mammoth	2	20.9	19.5	17.2	15.7	15.2	12.5	14.7	17.7
Clwyd	2	21.7	18.4	15.3	14.1	14.2	13.1	15.0	17.7
English Broad Red	6	21.5	18.0	16.2	14.0	15.5	13.5	15.3	17.7
Brittany	2	21.0	16.3	16.6	13.5	14.9	13.1	14.9	17.9
Chilian	2	22.2	18.1	16.4	16.0	16.2	15.0	15.3	17.4
Bohemian	2	20.2	17.2	15.2	13.9	14.8	12.5	14.1	16.9
American Medium	2	22.1	17.7	15.7	15.5	15.5	12.8	14.8	17.0
Italian	1	24.0	19.4	18.4	16.6	17.6	14.2	16.2	—
Wild	2	24.3	20.8	17.6	15.6	16.4	15.7	17.5	22.0

FIGURE II.—*To show the negative correlation between the yields of green fodder and percentage dry matter for the produce from eight monthly cuts in the case of three strains of Red Clover.*

The cutting dates are shown for each strain separately by simple numerals, as follows:—1 = March 5th; 2 = April 2nd; 3 = May 2nd; 4 = May 30th; 5 = June 27th; 6 = July 26th; 7 = August 24th; 8 = September 26th.

Coefficients of correlation:

Montgomeryshire late	= — .823 ± .0793
Wild Red	= — .593 ± .1530
Swedish late	= — .739 ± .1080



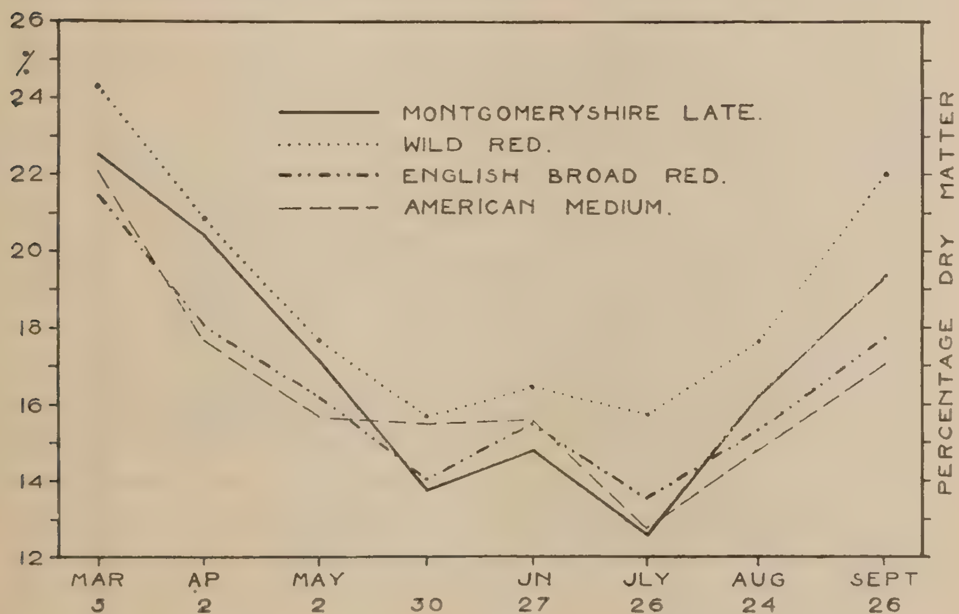
The coefficients of correlation between the green weights and the percentage dry matter for the eight pasture cuts in respect of four strains are given below:—

Montgomeryshire Late	— .8230 ± .0793
Swedish Late	— .7392 ± .1080
Wild Red	— .5986 ± .1530
English Broad Red	— .5960 ± .1530

There are, therefore, very definite negative correlations between the green weights and the percentage dry matter of the pasture cuts in the case of Montgomeryshire late and Swedish late, but the correlation, though present, is not so pronounced in the other two strains.

Figure III., which represents the frequency curves of the percentage dry matter for the different pasture cuts of four strains, demonstrates even more clearly than Figure II. the rapidity with which the dry matter decreased during the early periods of the growing season up to the end of May, then, for reasons not yet understood, the percentage dry matter of most strains made a decided recovery in the June cut in spite of the greatly increased yields, but in July it again dropped and this time to its lowest ebb. Then as the yields diminished with the advance of the season the percentage dry matter again increased, until by the end of September it had nearly reached the April level.*

FIGURE III.—*To show the percentage dry matter in each of eight monthly pasture cuts in the case of four strains of Red Clover.*



RATIO OF STEM TO LEAVES IN THE PASTURE CUTS. A glance at Table X. will show that on the average the most leafy growth was obtained in April and May, and that the July growth was decidedly the most stemmy. If the results given in Table X. are represented graphically bimodal curves such as are shown in Figure IV. are obtained, which in the case of the curves for the percentage stem have small modes in April or May and very pronounced modes in July.

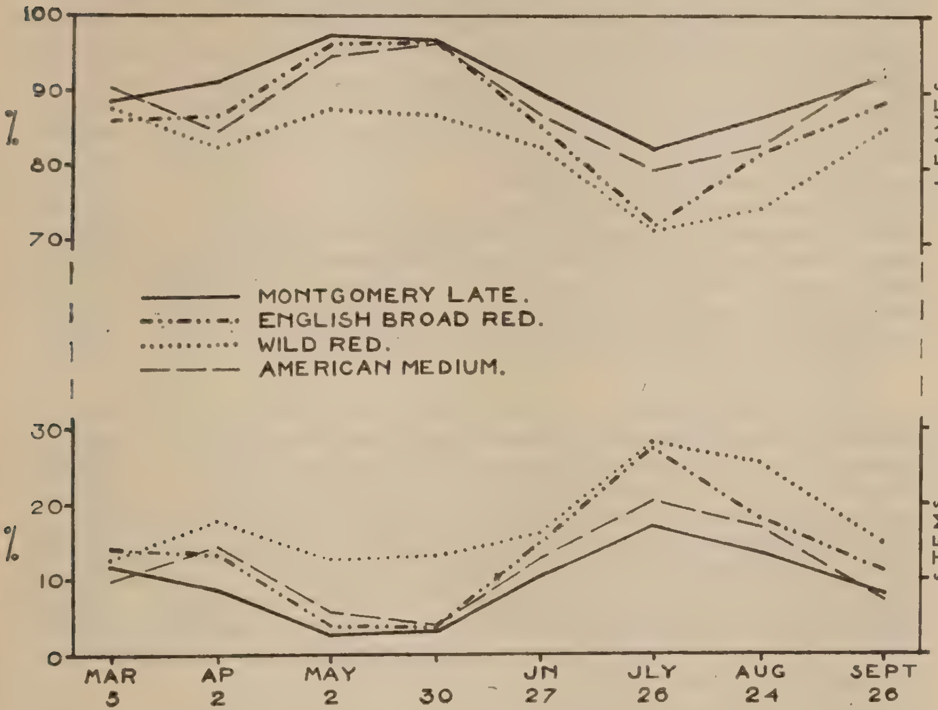
* See also the previous article dealing with grasses, p. 56.

TABLE X.—*To show the percentage amount of leaves present in each of the eight monthly pasture cuts.*

Percentages based on dry fodder.

Nationality.	No. of lots.	Mar. 5.	April 2.	May 2.	May 30.	June 27.	July 26.	Aug. 24	Sept. 26.
English Late Flowering ..	3	89.9	86.3	92.9	93.2	92.7	75.4	79.9	91.6
Montgomeryshire Late ..	1	88.3	91.3	97.3	96.2	89.7	82.5	86.6	92.7
Cornish Late	2	77.5	82.4	88.4	89.4	89.0	73.3	79.9	91.6
Swedish Late	2	91.6	92.7	96.1	95.2	86.2	81.5	91.4	93.5
American Mammoth	2	96.5	92.6	96.1	89.1	85.1	75.0	81.4	94.0
Clwyd	2	84.4	80.2	91.8	93.9	90.2	70.0	82.0	90.8
English Broad Red	6	86.0	86.8	96.4	96.6	85.5	72.5	82.0	88.8
Brittany	2	83.0	86.9	97.3	95.9	90.0	78.3	81.1	89.3
Chilian	2	88.4	87.4	96.7	96.2	86.2	72.9	75.6	91.0
Bohemian	2	89.1	81.3	96.2	96.5	84.4	72.2	83.4	90.0
American Medium	2	90.1	85.9	94.6	96.4	87.1	79.9	83.0	93.0
Italian	1	89.4	85.4	96.3	98.0	91.0	71.0	85.7	92.7
Wild	2	87.8	82.7	87.7	87.0	84.0	72.0	74.5	85.1

FIGURE IV.—*To show separately the percentage weight of stem and of leaves in total dry matter for each of eight monthly pasture cuts in the case of four strains of Red Clover.*



The figures given below are extracted from Tables VIII. and X. in order to determine if the periods of greatest stem development coincided with the periods of maximum growth on the one hand, and with the normal date of flowering of the strains on the other.

Strain.	Date of full bloom of the hay drills.	Percentage weight of stem.		Percentage yields (of aggregate yields).	
		26 June.	27 July.	26 June.	27 July.
American Medium ..	5th July	12.9	20.1	19.4	27.8
Wild	6th ,,	16.0	28.0	26.7	29.9
English Broad Red ..	14th ,,	14.5	27.5	15.2	28.5
Bohemian	16th ,,	15.6	27.8	17.5	34.8
Swedish	26—28th ,,	11.0	26.7	25.2	23.2
Montgomeryshire Late..	28th ,,	10.3	17.5	29.2	28.2
American Mammoth ..	3rd August	14.9	25.0	27.2	26.3

It is evident from these figures that there is no close connection between yield and the percentage stem formed during June and July, and that there is no

relation between the normal time of flowering of the different strains and their percentage weights of stem. Yet from the observations made on the pasture drills it was clear that there existed a close relation between the extent to which the pasture drills flowered and the high stem development. On the 26th June only a very few plants had made any attempt to flower, but during July all the strains flowered very freely in spite of the very small growth made as compared with the hay crop. It seems, therefore, that the repeated cutting had the effect of delaying the flowering of the early strains by several weeks, with the result that all the strains, both lates and earlies, ran into flower at about the same period under pasture conditions.*

The percentage weights of leaves in the aggregate pasture yields of the different strains do not present any striking differences except that the Wild Red proved much more stemmy than any of the commercial strains. The most leafy pasture yields were given by two late strains—Montgomeryshire and Swedish. The late strains, which gave an average figure of 86.51 per cent., were slightly more leafy than the early strains, which had an average of 84.16 per cent. leaves

THE PRODUCTION OF FLOWER HEADS UNDER PASTURE CONDITIONS. Some interesting figures having a direct bearing on this point are given in Table V. Despite the short and dwarfed nature of the plants as a result of repeated cuttings, these counts show that the actual number of flower heads (open and in bud) per 1000 grams of green fodder was greater and in some strains, especially in Wild Red, very much greater in the pasture cuts of July 26th and August 24th than in green hay cut at full bloom. These facts are interesting as showing even when the plants are severely taxed almost to the point of exhaustion by constant cutting, they are none the less responsive to periodic growth influences affecting the production of flower heads and this is particularly well marked in the case of Wild Red.†

COMPARSION BETWEEN HAY AND PASTURE CUTS. RELATIVE PRODUCTIVENESS UNDER HAY AND PASTURE CONDITIONS. In drawing a comparison between the productivity of red clover under hay and cutting conditions it should be borne in mind that with the clovers, just as the grasses, the effect of repeated cutting is probably more exhausting on the plants than even the heaviest of grazing, and for the reasons that have been discussed in the previous article.‡

By referring to Table XI., which gives the weights of green hay and the aggregate pasture yields, and also the percentage weight of pasture to hay, it will be seen at a glance that the average weight of hay is about three times as much as the weight given by the sum of the pasture cuts, and if the yields are expressed in terms of total dry matter, this difference is still further accentuated. The average percentage weights (dry matter) given by the aggregate pasture cuts to the average hay weights for the three major groups of red clover are given below :—

	Hay.	Pasture.
Lates (5 strains)	100	23.0
Earlies ,, (excluding Italian)	100	33.2
Wild	100	30.7

* See previous article dealing with grasses, p. 31.
† See previous article dealing with grasses, p. 31.
‡ See page 11.

TABLE XI.—*To show the average Hay (1st cut only) and Pasture yields in oz. of green fodder per 10 feet drill, and the percentage weight of "pasture" to "hay" yields of different nationalities of Red Clover during the 1st harvest year, 1923.*

Strain and Nationality.	No. of lots.	Green weight oz. per 10 feet.		Percentage weight of Pasture to Hay.
		Hay.	Pasture.	
English Late Flowering	3	202.5	52.3	25.8
Montgomeryshire Late	1	208.5	79.1	37.1
Cornish Late	2	248.3	78.4	31.7
Swedish Late	2	291.7	89.0	30.5
American Mammoth	2	265.3	63.2	23.8
Clwyd	2	177.3	84.7	47.8
English Broad Red	6	143.4	61.0	42.6
Brittany	2	136.9	44.0	32.2
Chilian	2	136.8	32.0	23.4
Bohemian	2	161.9	69.5	43.0
American Medium..	2	140.7	64.3	45.7
Italian	1	58.3	10.5	18.0
Wild	2	140.7	53.8	36.5

The higher ratio of pasture to hay of the early strains is probably explained by the fact that the aftermath yields, which in a normal year would be very much heavier in the early than in the late strains, are not included in the hay weights.

If the pasture to hay ratio can be considered as a fair criterion of the ability of the different strains within the major groups to withstand pasture conditions, then Montgomeryshire and Cornish lates have stood the test better than the other three late strains, while the intermediate strain—the Vale of Clwyd, and American Medium, Bohemian and English Broad Red of the early flowering group may be considered as being much more suitable for grazing purposes than Brittany, Chilian or Italian.

It will be of interest in this connection to compare the 1923 results with those given by a similar experiment in 1922. In the 1922 experiment four early strains, namely, English, American, Chilian and Bohemian, and four late strains—English, Montgomeryshire, Swedish and American, all in the third year of growth (2nd harvest year) were cut twice as hay and aftermath and four times as pasture during the growing season. The ratio of the aggregate green weights yielded by the four cuts to the hay *cum* aftermath yields for the two groups of clovers were :—

	Hay and aftermath.	Four cuts.
Late strains	100	69.1
Early strains	100	58.5

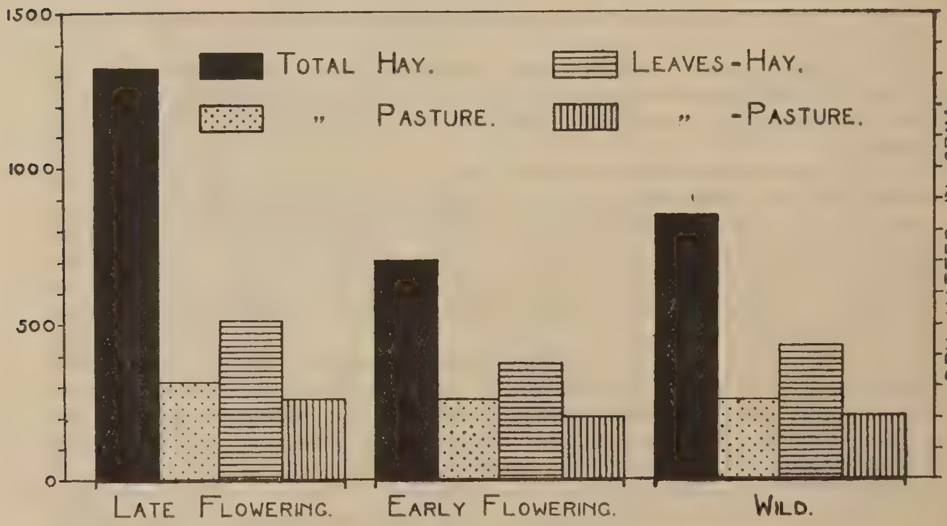
These results, when taken in conjunction with the 1923 figures given above, demonstrate two facts of great practical significance, (1) that in order to obtain the maximum weight of fodder, red clover should not be cut more than three times, and possibly only twice, during the season. The stages at which these cuts should be made in order to obtain the heaviest yields has not yet been determined, but it seems probable from the data already available that the first cut should be made during the early flowering stage as has proved to be

the case with Lucerne ; (2) eight pasture cuts taken during the growing season had a much greater depressing effect on yield than four cuts.*

COMPARISON OF THE PERCENTAGE DRY MATTER IN HAY AND PASTURE. As shown by the percentage figures given in Table IV., the percentage dry matter was in all the strains consistently lower in the aggregate pasture cuts than in the green hay. As may be seen from Table V. the differences in favour of the green hay were about 4 per cent. in both the late strains and Wild Red, but in the early strains the average difference was only 1.54 per cent., with a range of from 0 to 3.2 per cent.

It seems probable that the differences between the percentage dry matter in the green hay of the various strains are definite varietal characteristics which in the pasture cuts are more or less masked (except in wild red) by the very succulent nature of the produce.

FIGURE V.—*To show graphically the average weight in grams. per* 10 *foot drill of total dry matter and of total dry leaves given respectively by the hay and the sum of the pasture cuts in the case of the three chief groups of Red Clover.*



LEAVES AND STEMS IN HAY AND PASTURE. It is clear from the figures given in Table IV., that the hay and pasture cuts differed essentially in the relative amount of leaves they afforded, and as shown in Table V. the dry hay of the late strains contained only 39.4 per cent. leaves as compared with 86.5 per cent. leaves given by the pasture cuts. The average figures of 52.8 per cent. leaves in the hay and 84.2 per cent. in the pasture cuts for the early flowering strains, although not so striking as the results given by the late strains, nevertheless prove that even in the early strains the hay is far more stemmy than the pasture yields. Although the hay contained as much as two-thirds to

* See previous article on grasses, p. 32.

one-half of stem, while the pasture cuts were predominantly composed of leaves, yet as shown in Table I. and Figure V. the hay cuts actually gave about twice as much leaves as the aggregate of the pasture cuts.

SUMMARY.

(1) The late strains produced much heavier hay crops than any of the early strains. Of the former strains the Swedish, American Mammoth and Cornish Marl Grass gave the heaviest hay yields, and of the intermediate and early strains, the Vale of Clwyd, Bohemian and English proved to be the most productive. Italian gave an exceedingly poor hay crop, which was only about one-sixth of that yielded by Swedish Late. The Wild Red yielded a slightly heavier hay crop than the average weight given by the early strains.

(2) The green hay of Wild Red contained a higher percentage of dry matter than that of any of the commercial strains. Again, on the average, the green hay of the late strains had 2.36 per cent. more dry matter than that of the early strains.

(3) The average percentage weights of leaves in the hay yielded by the early and late strains were 52.84 and 39.36 per cent. respectively. Although the hay produced by the early strains contained a much greater proportion of leaves than that of the late strains, yet the latter, by virtue of the much greater bulk of hay which they produced, actually gave a much greater weight of leaves per unit area than the former.

(4) The late strains developed flower heads in greater abundance than the early strains ; the Wild Red flowered even more freely than the late strains.

(5) Under conditions which approximated to close grazing, the early strains were again excelled by most of the late strains, but the superiority of the late over the early strains was not so pronounced under cutting conditions as when they were cut for hay. Of the late strains, Swedish, Montgomeryshire late and Cornish Marl gave the best results, and of the intermediate and early strains, Vale of Clwyd, Bohemian, English and American Medium were much superior to Chilian, Brittany and Italian. Wild Red stood on a par with the poor late strains and the best early strains.

(6) During the winter and early spring of the seeding year and autumn of the first harvest year the keep afforded by the Wild Red was practically negligible, and during these periods the best early strains made much more growth than the late strains, with the exception of Swedish late. The maximum growth occurred during June and July, when 48.4 to 57.4 per cent. of the total pasture yields for the 12 months were obtained.

(7) For each strain there was a more or less definite negative correlation between the weights yielded by the monthly pasture cuts and the percentage dry matter of the monthly produce. The March and April cuts which gave the poorest yields had the highest percentage dry matter. Thus as the yields increased during May, June and July, the percentage dry matter decreased more or less correspondingly, and as the yields decreased during August and September the percentage dry matter again increased.

(8) The productivity and the percentage dry matter in the aggregate pasture yields of the different strains were intimately connected. The most productive strains had the lowest percentage dry matter and *vice versa*, with the result that any varietal differences that may exist in the percentage dry matter are masked by this negative correlation.

(9) The aggregate pasture cuts of the late strains were slightly more leafy than those of the early strains. Wild Red was decidedly more stemmy than any of the commercial strains. In all strains the pasture produce was more leafy during the spring, early summer and autumn than during mid-summer.

(10) When cut four times during the growing season, the late strains yielded 69.1 per cent. and the early strains 58.5 per cent. of the produce taken as a hay cut, but when cut eight times during the growing season, the ratios between the aggregate pasture cuts and the hay yields of the late, early and Wild Red strains were only 23.0 per cent., 33.2 per cent. and 30.7 per cent. respectively. It is evident from these results that Red Clover is not capable of withstanding repeated close cutting, and thus it would appear to be more essentially a hay than a pasture plant.

(11) The percentage dry matter in green hay ranged from 16.7 to 21.2 per cent., according to strain, while the dry matter content of the pasture cuts varied from 13.9 to 17 per cent. Thus the bulk of fodder obtained under cutting conditions was not only much smaller, but it was also more watery than the green hay.

(12) According to Pieters (21)* the leaves of Red Clover contain about three times as much protein as the stems. It is therefore evident, since the aggregate pasture yields contained as much as 77.4 to 89.5 per cent. leaves, while the hay only contained 38.2 to 55.6 per cent. leaves, that the pasture produce is of much greater nutritive value than a corresponding weight of hay, but as the hay crops, by virtue of the much greater bulk, actually produced about twice as much leaves as the pasture cuts, it is equally evident that the hay contained much more digestible nutrients per unit area than the pasture produce.

* See list of literature cited at the end of the bulletin.

A Note on Subterranean Clover (Australian Variety).

by

R. D. WILLIAMS, B.Sc., and WILLIAM DAVIES, B.Sc.

Subterranean Clover (*Trifolium subterraneum*) has been under trial at the Station since 1920, and is in many respects an interesting forage plant. It has an exceptional ability for establishment from self seeding, and this fact has largely been made use of in Australia in connection with seeding out on poor sandy soils.*

EXPERIMENT E. 53.

The extent to which Subterranean Clover, although an annual plant, can maintain itself on a sward under suitable conditions was demonstrated at the Station in rather a curious way.

It has been the practice at the farm to seed out odd corners which are unsuitable for plot work. A particularly steep and shallow bank with a soil depth of no more than 2-in. or 3-in. was thus sown out on May 8th, 1922. Two mixtures were used, both being made up with the residue of seed left over from

* The following facts relative to the use of Subterranean Clover in Australia are of interest. In answer to a request for information, Dr. Wm. Laidlow, Government Botanist, National Herbarium, Victoria, kindly informed us that probably the plant was first introduced into Australia as an impurity in agricultural seed, it was recorded as a naturalised alien in Victoria in 1887-8. At first the plant was regarded as chiefly useful for the repression of useless weeds, but recently it has come into prominance as a pasture plant being so used in Victoria, South Australia and Tasmania. We are also favoured by information from Mr. J. B. Clarke of Piggoreet West, Victoria, who states that it is a wonderful fodder plant, the seed appears to be of high germinating capacity, and if only ½-lb. of seed is sown with mixed grasses, by self establishment from re-seeding it soon gives rise to a dense sward. Further information is given by Audas (2), and by Brunning (4). It is stated that Subterranean Clover makes excellent hay, and that on pastures stock are particularly fond of it, sheep grazing the young plants freely, they are also fond of the haulms and seed pods, which are of considerable value in droughty summers ; cattle are perhaps most fond of it just after the wilting stage. Its value for weed suppression is emphasised, and it is pointed out that it succeeds well on a poor dry sandy and gravelly land, where the rainfall is over 20 inches annually. The plant being an annual and depending on self seeding to perpetuate itself, it is recommended that it be allowed to fully flower and seed during the first season after sowing, and when cutting the hay it is necessary to leave rather a long stubble. Makin (16) advocates a sowing of 12 lb. per acre if broadcast alone and 4 lb. per acre if sown with other plants.—R.G.S.

various experiments. One of these mixtures which was sown on about ¼-acre included a little Subterranean Clover, the mixture in lb. per acre was approxmately as follows :—*

Indigenous and New Zealand Cocksfoot	.. ..	16 lbs.
Indigenous Perennial Rye Grass	.. ..	8 ,,
U.S.A. Timothy	.. ..	4 ,,
Irish Crested Dog's Tail	.. ..	2 ,,
Montgomery Late Red Clover	.. .. ..	4 ,,
Wild White Clover	.. ..	1 ,,
Subterranean Clover	.. ..	2 ,,

The mixture was broadcast by hand, and then chain harrowed as the only covering operation, the ground being too steep to roll.

Seeding Year (1922).—Notes were taken on November 9th in the seeding year, when it was evident that the take had been satisfactory, and this was particularly marked in the case of Subterranean Clover, even on the steepest slope and on the shallowest soil, there being on the average 3 to 5 plants per square foot. Individual plants had formed quite dense mats, and in many cases runners of 18-in. had been sent out—the longest span measured from the tip of one runner to that of another across the middle of the plant was 44in. The plants were flowering freely on November 9th, but not very much seed had been developed.

The area was grazed by sheep from November 9th to 18th, the sheep showing a particular partiality for the Subterranean Clover, which was eaten to ground level.

First Harvest Year (1923).—The whole area was again grazed by sheep from February 26th to March 12th. It was found necessary during April to run a rabbit netting across the field to protect the main experimental area. In order to make a straight run this fence divided the corner on which the mixtures had been sown into two portions. The smaller portion inside the experimental area was of necessity allowed to run to hay, while the larger portion outside was grazed by sheep off and on throughout the summer.

The plants of Subterranean Clover on the pasture area were grazed very closely by sheep all through the summer, and it was noted at the time that they only flowered to a limited extent. On the hay portion the plants flowered and set seed freely, with the result that by the end of September or early in October, this portion was densely covered with seedlings—while on the pasture portion there were comparatively few seedlings present.

Second Harvest Year (1924).—Notes were again taken during February, and it was found that the seedlings of Subterranean Clover had survived the winter and were healthy and green, the difference between the hay and pasture portions being so striking that it was decided to ascertain the number of plants per unit of area on each portion.

On March 7th, five representative quadrats each of 1/400 acre were marked out on the larger pasture portion and four quadrats of similar size on the smaller

* The seed rate was advisedly heavy because much of the seed employed was of poor germinating capacity.

hay portion. One quadrat on each portion was taken close to the boundary fence. Ten properly distributed readings were made on each quadrat with a mesh 6-in. by 6-in. The average results were as follows :—

Hay portion 25.7 plants per square foot = 1,119,500 plants per acre.
Pasture ,, 3.8 ,, ,, ,, ,, = 165,500 ,, ,, ,,

The greatest number of plants per ten readings (6-in. by 6-in.) on the pasture area was 19, and the least number on the hay area was 51. The hay and pasture quadrats close to the fence were as distinct from each other as any others situated respectively in the two areas.

EXPERIMENT E. 33 I.

In order to test the effect of date of sowing on soil germination and establishment a number of the chief herbage plants were sown every fortnight in the gardens from March 1st to October 25th, 1923.

The lots were sown in five foot drills, each drill being replicated three times for each sowing date. The seed rate was for each species ten viable seeds per inch.

Fortunately Subterranean Clover was included in the experiment, and the chief results with respect to this species are worthy of detailed consideration.*

Soil Germination, Brairding and Establishment.—Frequent notes were taken on the drills, and counts were made of the number of plants reaching maturity. The chief results are given in Table I. It will be seen that the time taken for germination was very uniform, being for the six growing season months (April to September) an average of 7 days. In March, and again in October, the period required was twice as long. Brairding was also slow from March sowings, and was only maintained at a more rapid rate from April—July sowings, drills sown in August and September taking as long to braird as those sown in March.

TABLE I.—*To show the average time taken for soil germination and full brairding. The number of plants, as a percentage of the viable seed sown, which became fully established is also shown.*

Month of sowing and number of sowings.		Days from sowing to germination.		Days from sowing to brairding.		Relative establishment as a percentage of viable seed sown.	
March	(3)	17		53		65	
April	(2)	8	Average = 7 days.	41	Average = 40 days.	74	
May	(2)	9		45		60	
June	(2)	6		39		70	
July	(2)	8		37		66	
August	(3)	8		54	Average 54 days.	66	
September	(2)	5		54		67	
October	(2)	14		‡		38*	21
						4†	

* 1st October sowing.
† 2nd October sowing.
‡ In seedling stage throughout the winter.

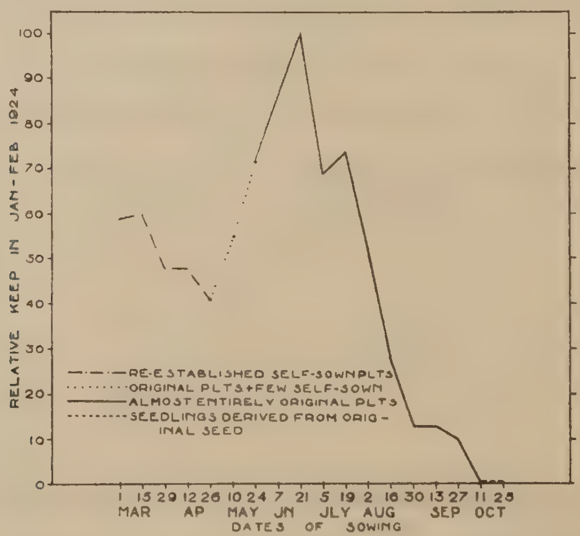
* The complete experiment will not be reported upon until after the termination of the present season.

There was practically no difference in final establishment between the various sowings from March to September, the average for the whole period being 67 per cent. of the viable seeds sown. The October sowings, however, gave very poor results, the earlier sowing of that month only giving an establishment of 38 per cent., and the later sowings no more than 4 per cent. of the viable seed. Subterranean Clover was also sown under winter oats on October 23rd, 1922 (A. 68), in this case considering the lateness of the sowing the establishment from a heavy seeding was surprisingly good, though doubtless only representing a small proportion of the viable seed, and the seedlings remained remarkably winter persistent, being far superior to red clover in this respect and in establishment. The plants came into full flower in July, 1923, and re-establishment had been assured by December of that year, when again the seedlings showed themselves to be exceedingly winter resistent.

Re-establishment from Self Seeding.—The amount of winter keep given by the drills from each sowing date is shown in Figure I. The yields were estimated on February 4th, 1924, by careful notes (on a scale of 10) and are expressed as a percentage of the maximum yield (the second of the June sowings).* The figure also shows whether the plants contributing to the winter keep were the original plants derived from the seed sown, or the direct self sown progeny of same.

FIGURE I.—*To show the winter keep (January 4th, 1924) from drills of Subterranean Clover sown at 18 fortnightly intervals in 1923.*

The yields are expressed as a percentage of the maximum yield (given by the drills sown on June 21st). Nurseries. 1924.



* The height of the plants on the drills was also taken at this date, and if plotted would have given a curve precisely similar in form to the yield curve shown in the figure.

It will be seen that from the March and April sowings the plants in the drills by February, 1924, consisted only of self established progeny of the originals. The drills sown in May consisted partly of the original plants and partly of self established progeny. Drills sown in June and until the end of September consisted practically only of plants derived from the original seed. while those sown in October contained only a few plants, hardly out of the seedling stage, derived of course from the original seed. Sowings made in March and April, and to a lesser extent early in May thus give rise to plants which flower and set seed freely during the late summer, while sowings made later in May and through June, July and August, give plants which in the main make active vegetative growth only, and do not flower to any great extent during the seeding year.

TABLE II.—*To show the relative winter keep of Subterranean Clover* (4 *consecutive sowings*), *Italian Rye Grass and Suffolk Broad Red Clover.*

Italian Rye Grass expressed as 100. Nurseries, 1923.

	Subterranean Clover. May, 1923. 10th	Subterranean Clover. May, 1923. 24th	Subterranean Clover. June, 1923. 7th	Subterranean Clover. June, 1923. 21st	Italian Rye Grass. May.	Suffolk Broad Red Clover. April and May.
4/2/24. Winter keep ..	53	70	83	97	100	40

Winter and Autumn Keep.—The relative winter keep from Subterranean Clover sown at different dates in May and June is compared with Italian Rye Grass (placed at 100) and with Suffolk Broad Red Clover (from the sowing dates at which these latter species gave the best results) in Table II. It will be seen in the first place from Figure I. that sowings of Subterranean Clover made during March and April, provide very little winter keep, this was to be expected, since the plants on the drills in winter were due to self seeding during the late summer. March and April sowings of course provide very considerable summer keep. May sowings provide very abundant autumn keep, cuts made on September 21st showed May sowings of Subterranean Clover actually out yielding May sowings of Italian Rye Grass. The June sowings provided the most winter keep, that made on June 21st actually giving in February, 1924, nearly as much keep as Italian Rye Grass (a plant of outstanding winter productivity) and vastly more keep than Suffolk Broad Red Clover.*

It will be noted that winter keep falls off rapidly when sowings are made after the end of June. This was also well shown by results from another experiment (E.21) when Subterranean Clover was shown on August 1st, 1922, the amount of keep during March, 1923, although greater than that from Broad Red Clover sown on the same date, was hardly a tenth of that given by Italian Rye Grass. The winter keep from sowings made in May were considerably less than from those made in June. It should be pointed out, however, that the May sowings had made so much autumn growth that the drills were cut on September

* The greater keep from Subterranean Clover than from Red Clover was also well shown in the case of experiment E.53 previously referred to, the keep in the sward from the latter species during January, February and March being almost negligible, while from the former it was very appreciable.

21st, while the June sowings were not then sufficiently luxuriant to be cut. Data obtained on another experiment (A.76) showed that Subterranean Clover sown in May and not cut back reached full maturity in the autumn, but too late to develop much seed and the plants, already adult, were soon killed by subsequent frosts. Consequently in the case under review if the plants had not been cut back in September the winter keep from May sowings would have been negligible—such a sowing date being too late to allow of re-establishment from self seeding, and too early to inhibit flowering and attainment to the adult condition in the seeding year.

Subterranean Clover is a wonderfully winter green plant, and this was equally true of the re-established self sown plants from March and April sowings and from the original plants derived from sowing in June and subsequently. The only burned plants were the practically dead originals from the March and April sowings.

Results when sown under Spring Oats.—When sown under Oats on April 22nd of that particularly wet year 1920 (E.9), Subterranean Clover did not flower and set seed to any appreciable extent before the Oats were harvested, with the result that the original plants were very luxuriant on the stubble—the plants giving higher autumn yields than those of the best Red Clover sown under like conditions. Sown under Oats on April 4th in 1922, a year with a dry spring (E.23), the original plants, however, flowered and seeded under the Oats with the result that young and re-established plants occupied the ground on the stubble, so that both the autumn and winter keep was almost negligible.

SUMMARY AND CONCLUSIONS.

(1) Subterranean Clover is an annual plant, and is to be regarded as a typical " winter annual." The seeds are of high average viability, germinate well and quickly in the soil and have a rather long seasonal range of establishment, March to end of September, subsequently establishment to a limited extent may be achieved from sowing made to the end of October ; in 1922, under winter Oats quite good establishment was obtained from sowing on October 25th. Thus under natural conditions seed ripening in the ordinary way in the summer buries itself and establishes new seedlings during the autumn, the plants maturing and flowering during the following summer.

(2) Plants that have not flowered or which have not flowered to any appreciable extent, and even seedlings of this clover are remarkably winter resistant. Plants that have flowered freely, even if too late to set and ripen seed, are rapidly and almost completely killed off by winter frosts. Plants that have fully flowered and ripened seed rapidly die, despite weather conditions.

(3) Subterranean Clover has been freely grazed by sheep at Aberystwyth, and is undoubtedly a forage plant of great value. It would seem to have two distinct applications (*a*) For use as a catch crop to provide keep at any particular season required, regulated by date of sowing, and (*b*) For inclusion in mixtures for temporary leys—reliance being placed on re-establishment by self seeding from comparatively small sowings in an original mixture.

(4) Unfortunately, at present, the seed available in this country is very expensive (6/- to 10/- per lb.), too expensive to allow of Subterranean Clover being an ecomonic proposition for use merely as a catch crop.

(5) Regarded as a catch crop (and assuming seed supplies became available at say about the price of Crimson Clover), its greatest value, particularly in districts where "grass-sheep" are an important feature of the husbandry, would be to provide late autumn and winter keep :—

(*a*) To provide maximum mid-winter keep the plant should be sown in June, preferably about the middle of June (West-Wales).

(*b*) Sown in May or early June, it will provide relatively abundant late summer and autumn keep, again becoming fairly productive in the winter.

(*c*) Sown in March or April it will provide abundant summer keep.

(*d*) Sown at the correct time it will provide as much or more autumn keep than Broad Red Clover, and sown at the correct time (late June) it will provide altogether more winter keep than Broad Red Clover—coming surprisingly close to Italian Rye Grass in this respect.

(6) For use in seeds mixtures for temporary leys, certain precautions have to be taken to ensure re-establishment.

(*a*) Re-establishment may be chiefly aimed at during the seeding year or during the first harvest year.

(*b*) If re-establishment is to be chiefly aimed at during the first harvest year :—(i) the seeds mixture must be sown early enough to ensure some re-establishment during the seeding year—that is to say, it must be sown in March or April, and it would be so sown in the ordinary way under Oats. In very wet years (*e.g.*, 1920), the original plants will probably not have seeded in the corn, and if grazed after the corn harvest will themselves over-winter into the first harvest year, or (ii) the seeds mixture must be sown late enough to prevent the plants coming to maturity during the seeding year, *e.g.*, after the middle of June, such a mixture could be sown under rape. May is a very risky month to sow Subterranean Clover with a view to re-establishment. The plants, if left to themselves, will probably flower and die without setting much seed—May sowings must therefore be grazed heavily in the autumn to prevent flowering and to ensure over-wintering.

In normal years if the mixture has been sown in March or April the field must only be lightly grazed during the autumn of the seeding year, otherwise initial re-establishment will be jeopardised ; if sown in June reasonable autumn grazing will not interfere with the results to be aimed at during the first harvest year.

The field must be put up to hay in the first harvest year when abundant re-establishment for the second harvest year will result. As little as 2 lb. per acre of Subterranean Clover included in a mixture under either of the above methods of procedure, particularly under the former, when there will have been initial re-establishment, may be expected to provide for an abundant sward of the clover in the second harvest year ; (iii) If strong re-establishment is desired in the first harvest year, the mixture should be sown in March without a nurse crop, and allowed to run to "hay" in the seeding year : when strong re-establishment may be expected from sowings of no more than 1 lb. per acre, and by the second harvest year results as good as the previous methods may be expected.

(7) If hay is not taken in the second and subsequent harvest years, the fields should be given adequate periods of rest to enable the clover to set and ripen seed.

(8) It should be emphasised that the experiments under review have been conducted in a district of high rainfall, the weather conditions have therefore fulfilled the requirements for re-establishment indicated by the Australian writers, and the results must not be taken as necessarily applicable to regions of low or even relatively low rainfall. In this connection it is interesting to remark that Yellow Suckling Clover (another typical winter annual) is a particularly abundant plant in the grasslands of West and Central Wales.

Grassland and the Grazing Animal.

by

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The comparative value of different types of grassland in relation to the production of milk, meat and bone, and indeed the productive capacities of individual fields as estimated by their earning power when the herbage is converted into animal products, is generally recognised as varying over the widest limits.* The farmer is, however, too prone to assess the complicated reaction betwen animal and pasture only by an estimate of the influence of the pasture on the animal, and to ignore the effect, equally important in the long run, of the animal on the pasture.

It has long been recognised in a broad way that the grazing animal exerts a profound influence on the floristic composition of the herbage. That this is in fact so is shown most strikingly by a study of areas once under cultivation that have been allowed to become derelict, and from which during the whole period of reversion the grazing animal has been completely withheld.

Brenchley and Adam (3) have shown for instance, that such areas at Rothamstead present an entirely different appearance, and have an entirely different floristic composition to that associated with fields that have been allowed to " find their own swards " from a wheat or oat stubble under the influence of the grazing animal. Similar cases have been studied by one of us at Cirencester,† while Farrow (8) in an interesting series of articles has shown the remarkable influence exerted by grazing animals—represented by rabbits—on the floristic composition of considerable areas in Breckland.

It is, of course, one thing to withhold animals completely from " reverting " areas and quite another to manage different fields differently in respect of the grazing animal. It is, however, generally recognised that permanent meadows and permanent pastures even on very similar soil types are floristically widely different from each other—thus extremes in management are easily recognisable in extremes of floristic composition. It is to be expected if extremes in methods of management exercise glaring and obvious influences on the botanical composition of swards, that more refined variations in management would still stamp themselves on the floristic characteristics of the sward, though doubtless to a less striking extent. That this is so is well shown by the relation of excess of

* The extent of this variation has been strikingly shown by estimates made by Sir Thomas Middleton (18) and (19).

† For an account of these areas, together with a further discussion of the influences of the grazing animal on the botanical composition of swards, see Stapledon (27).

Yellow Rattle and Yorkshire Fog to consistent late cutting of the hay harvest. Extreme practices in regard to the management of grazing animals on areas wholly devoted to pasture are also in a general way recognised as influencing the botanical composition of swards. Thus areas devoted entirely to sheep or entirely to deer will reveal these malpractices in unmistakable botanical language.

It is probable, however, that far less exaggerated practices still react on the botanical composition of the sward—and in particular there is considerable evidence in support of the view that the degree of heaviness of stocking, particularly at certain times of the year, or in particular seasons, may have a very real floristic influence and an accumulative influence when such practices are continued on a more or less uniform plan year after year. The evidence brought forward in the first article of this bulletin which proved that repeated cutting, particularly when started early in the spring, had a very pronounced effect on the persistency and yielding capacity of the larger and earlier grasses, is significant in this connection. Tall Oat Grass and Cocksfoot, for instance, are not usually found in quantity on permanent pastures ; the former species is only at all abundant on very inferior pastures which are but slightly grazed, such as those almost dominated by Dyer's Greenweed (*Genista tinctoria*) on the very heavy clays in the South of England, while the latter is more essentially a meadow plant.* It is also a common experience that on fields heavily grazed early in the spring, neither Cocksfoot, Tall Fescue or Tall Oat Grass remain persistent when included in seeds mixtures.

Sinclair (25)† has reiterated again and again the harm done to grasses by vigorous cutting prior to the heading stage, and there can be little doubt that heavy grazing exercises a similar effect—an effect which is probably most marked on the grasses making the most abundant early growth—generally speaking the larger grasses, such as Tall Fescue (never abundant on heavily grazed pastures), Tall Oat Grass and Cocksfoot, thus it would seem highly probable that heavy grazing early in the spring should be regarded as a very important factor influencing the floristic composition of swards. There is evidence for thinking that even the finer and later grasses are also harmed by heavy early grazing, particularly in cold and dry springs. One of the present writers has has been struck by the particular abundance of daisies in pastures in the neighbourhood of his own house in the spring of 1922 and 1923, and it has been observed that the greatest abundance has occurred on poor soils heavily grazed by sheep all through the early spring and summer of dry 1921. Since such fields have been more heavily grazed than meadows, on apparently similar soil types, it would seem justifiable to assume that the heavy grazing equally with the drought must be regarded as a factor partly responsible for the considerable floristic change in such swards.

It is probable, however, that the selective effect of heavy early grazing is chiefly operative, or at all events most apparent, on developing swards, say in the first and second harvest years from a seeds mixture. On permanent

* In this connection it is of interest to note that both at Rothamstead and Cirencester on the areas allowed to revert without the influence of the grazing animal, Tall Oat Grass has been noted as abundant.

† He remarks for instance . . . . . "that nothing weakens or retards the growth of grasses "so much as cropping them close at the time their first tender shoots appear in the "spring," and later he expresses himself even more strongly, stating "It appears "therefore that no stock should be admitted to seedling grasses until after the time "of their coming into flower."

pastures the effect is masked because in the language of Sir John Sinclair (24)* the swards will have " accustomed themselves " to the prevailing practices, and will have become dominated by species (some of them grasses and few if any of them heavy yielding) best able to withstand the conditions super-imposed.

The evidence derived from the repeated cuttings, admittedly drastic as they were, should serve therefore to concentrate attention on the effects of early heavy grazing and afford additional support for the view that it is fatal to the establishment of a satisfactory temporary ley to graze it heavily during the spring (late March and April) of the first harvest year.

From the above brief review it would appear that the grazing animal itself (as controlled by the hand of man) exerts a very real influence on the ration offering on any particular field at any particular time—even when that ration is merely estimated by the floristic composition of the herbage.

It is equally evident, however, from the results presented in the previous articles that the grazing animal must exercise as profound, or even a more profound influence on his ration, through the reaction of each individual species to hay or pasture conditions, to heavy or light grazing. It has been shown firstly, that frequent cutting makes for a leafy herbage, and secondly, that leaf at practically all stages through the grazing season has a higher nutritive value than stem. Thus heavy grazing, which undoubtedly makes for a leafy sward at any particular time *ipso facto* makes for a nutritious sward. It has been shown also that the nutritive value of both stem and leaf frequently cut is greater than that less frequently cut, and further that the percentage dry matter is less in frequently cut than in infrequently cut herbage. It is thus apparent that the ration afforded at any particular time on any particular field is a variable of at least four dimensions :—(1) the botanical composition of the sward ; (2) the ratio leaf to stem ; (3) the nutritive value of both leaf and stem, and (4) the moisture content of leaf and stem ; and further, that every one of these characteristics of the ration is influenced by systems of cutting, and

* Sir John Sinclair in " The Code of Agriculture " expresses himself as follows :—" It is " indeed an important maxim in the management of grazing land, not to adopt the plan " of mowing and feeding alternately. In this way, a farmer may go on longer without " the application of manure, but his fields, in the end, will be ruined by it. To " maintain a proper quantity of stock, the land must be accustomed to keep it ; " the more it has kept, the more it will keep ; four sheep this year, five the next ; after- " wards more, with the addition of manure. Land that has been used to the scythe, " will often produce more grass, but that will not (*caeteris paribus*), support so much " stock, nor fatten them nearly so well, as an old pasture, though it may have been " better manured ; nor will old pasture produce so much hay as the other ; for each " will grow *as they have been accustomed to grow*, and will not readily alter their habits."

The above passage is so intimately linked even with modern practices in regard to grassland that it deserves to be quoted *in extenso*. It has, however, to be remembered that fields " accustom themselves " in both directions, and there can be little doubt for instance that fields heavily grazed by sheep all through every winter and every early spring have " accustomed themselves " to produce very little spring keep ; and that fields,—and particularly on poor soils—inadequately manured and cut too late for hay have " accustomed themselves " to produce very poor and weedy hay crops. Thus the doctrine implied in Sinclair's discerning passage should not be taken in a too narrow sense, for whilst under certain conditions both pastures and meadows " with prolonged practice " may become better and better ; under different conditions fields " accustomed " to either prolonged meadow conditions or to prolonged pasture conditions may have acquired " fixed habits " of greatly diminished productivity. The real significance of the " accustomed " point of view is that grassland is uniquely sensitive to management, granted the knowledge and the skill, therefore, there is no *a priori* reason why fields should not be made to " accustom themselves " to be of the greatest aggregate productiveness when used as pastures and meadows on an alternate basis.

therefore, although perhaps to a less marked extent, must inevitably be influenced by the grazing animal itself, and therefore by the system of control adopted by the farmer.

On a very closely grazed sward the animal is offered a relatively highly nutritious ration, but a relatively watery one—but the herbage will be scant and the animal will have to walk far and work hard to pick up an adequate maintenance allowance of dry matter, and to work harder and walk further to pick up a fatting allowance. On a less heavily grazed pasture the animal will not have to walk so far to pick up a maintenance allowance, nor probably so far to collect a fatting allowance as on the heavily grazed sward, but he will presumably have to use up more energy in the process of converting the less concentrated ration that he has acquired.

In the case of young stock, the fact of having to expend energy in collecting a ration from a scant herbage is probably, as such, without much significance—it becomes rather a question of whether the animal will have the time available to collect a maintenance ration at all—with fatting animals probably both "time taken" and "energy expended" are important factors.

Since the ration presented by a grazing field is so variable, the precise feeding value of any sward at any particular time is presumably not only to be estimated by an endeavour to arrive at a just balance between the time taken and energy required to collect a daily sufficiency of food, and the energy and time required to digest and convert it—but must also be affected by how well balanced the ration is when collected.

The variability of the ration as such is greatest on bullock or cow pastures, since these animals do not graze as closely as sheep, and is also most variable as it affects the animal, since horned stock do not show the same partiality as between stem and leaf as do sheep. It will consequently be advisable to consider cattle pastures and sheep pastures separately.

It is generally regarded as axiomatic that pastures are of their greatest fatting value (for beef) during May and June, and it is generally considered that during these months it is a wasteful extravagance to supplement the herbage ration with cake. The figures as to gross yield of stem and leaf together show that the great bulk of the herbage is produced during May and June, while the chemical analysis indicate that usually over half of the true and crude protein produced in the grazing season are supplied during these months, and thus in ordinary seasons on reasonably good grass the addition of cake in May and June would seem to be unnecessary from the point of view of supplementing the ration—the animal can collect a sufficiency of concentrates and collect them sufficiently quickly.

It is customary, however, to feed cake to animals which it is desired to fatten or bring to a forward condition on aftermath, and this is a practice which even those most adverse to the use of cake on grassland are hardly willing to condemn. It is probable that the use of cake on aftermath has come to be regarded as necessary, chiefly because the aftermath fatting season is of necessity a short one, and it is therefore important to hasten the fatting process as much as possible. It has been shown, however, that after-grass compared to pasture at equal date is very abundant, and indeed that the bulk of herbage may sometimes stand comparison with that developed on pastures in May and June. After-grass differs fundamentally from May-June pasturage, inasmuch as it consists predominantly of leaf, the amount of leaf as such being as great, or nearly as great, as on pastures in May or June, and therefore regarded as a whole

affords not only an abundant, but a decidedly concentrated ration.* It is therefore not improbable that the value of cake on aftermath may not only turn on its hastening influence, but it may have an important balancing effect on the ration counteracting any tendency of after-grass to cause the animals to scour—indeed, the hastening influence as such may be due to some indirect effect rather than to the addition of concentrates to a ration already abundant and concentrated.

When stem and leaf together are considered—as seems best when concerned with cattle grazing—it will have been seen from the chemical analyses that obviously it is the bulk of herbage produced rather than the seasonal differences in nutritive value that exerts the dominating influence on seasonal carrying capacity.†

No doubt the carrying capacity of different fields at any particular date, turn largely on the proportion of leaf to stem available. Other things being equal and the bulk as such being adequate, the greater the leaf per unit of area, probably the better, as instanced by the undoubted carrying capacity of aftermaths. It is evident from the above considerations that the time taken by the animal to collect an adequate ration is of supreme significance. In this connection it should be remarked that if the whole of the herbage of a field is palatable, the animal will collect his adequate ration more quickly than if the herbage, although equally abundant, consists partly of palatable and partly of unpalatable ingredients, thus palatability in common with other factors affecting the carrying capacity of swards has important indirect, as well as direct, influences.

It has been pointed out that excessive grazing early in the spring almost certainly reacts adversely on subsequent productivity, and on the persistency of the more bulky grasses. The chemical evidence, however, suggests that the nutritive value of the herbage on a field at any particular time varies more or less inversely with the maturity of that herbage. Thus the grazier concerned with fatting beasts on pasture has an interesting and difficult problem to solve. If he starts grazing too soon he risks an almost immediate shortage of herbage, when the animals will take too long to collect their ration, and he also risks doing lasting harm to his field. If on the other hand, he starts too late, he risks the herbage keeping too far ahead of his animals all through the season, it will always be a little too mature and not at maximum nutritive value. The obvious compromise would appear to be to start grazing rather lightly and some little time before heading stage, and increase the head of stock during heading and flowering stages, every endeavour then being made to prevent the sward becoming benty and mature.‡

* The chemical analyses of the aftermath hay crops do not of course represent the composition of the grasses under grazing throughout the aftermath period. The aftermath hay consists of relatively mature grass, while under grazing the herbage is of course kept young, and in percentage composition would compare with that from pasture cuts at the same dates, being equally concentrated and more bulky.

† Thus in June the percentage contribution of crude protein and of true protein tend to be at their lowest, while in September the percentage contribution of both tend to be as high or slightly higher than in May.

‡ The ill effects of allowing pastures to run to bent (flowering) are of course two-fold : the herbage becomes mature and by that much unpalatable and the plants are weakened by setting and ripening seed. The Leicestershire plan of introducing store animals after the first batch of fatting animals affords an excellent example of the weight enlightened practice attaches to preventing the herbage on pastures becoming over mature or benty, a risk that always has to be guarded against when pastures are rested too long early in the spring.

Although it would be an exaggeration to say that sheep never graze stem, it is an undoubted fact that leaf constitutes the overwhelming proportion of the ration taken by sheep from pastures. It would be expected, therefore, that the seasonal fluctuations of leaf as such independent of stem would show marked agreement with the seasonal carrying capacity of sheep pastures. The extensive manuring for mutton experiments afford direct evidence as to the seasonal productivity of sheep pastures. The results from six centres are shown in the Table hereunder.* The percentage live weight increase (of total increase for the grazing season) is shown for each month, the average results from all the plots at each centre being used in preparing the table.

TABLE I.—*To show the live weight increase per month throughout the grazing season for sheep at six different centres. The monthly increase is shown as a percentage of total increase for the season. Unless otherwise stated average figures based on all the plots at each centre have been used.*

THE REFERENCES TO LITERATURE CITED ARE INDICATED BY THE FIGURES IN BRACKETS.

Period, Centre and Authority.	Percentage of total live weight increase.					
	May.	June.	July.	August.	September	October.
1897—1905 at Cockle Park (10) ..	35.2	25.5	19.4	12.4	7.5	—
1900—1909 at Sevington (1) ..	30.7	24.5	21.5	12.4	6.8	4.1
1902 at Trowse, Norwich (31) ...	50.5	22.4	22.5	4.6	—	—
1904—1907 at Naemoor N.B. (12) ..	37.1	31.1	13.2	10.3	8.3	—
1913 at Cymmerau, West Wales† (13) ..	—	—	68.6 (1st)	*	*	—
1914—15 at Hafod, West Wales‡ (13) ..	—	50.0 (1st)	*	*	*	—

* Subsequent weighings at irregular intervals.
† On unmanured plot at 900 feet above sea level.
‡ ,, ,, ,, 1000 feet ,, ,, ,,

It will be seen that there is considerable uniformity between all the centres, and that in round figures two thirds of the total live weight increase for a whole season has been accounted for during late April, May and June. It is rather difficult to reconcile this "verdict" of the manuring experiments with the botanical and chemical evidence discussed in this bulletin. It is true that under such drastic systems of cutting as seventeen and twenty times per season the leaf has fallen off sufficiently to account for, or more than account for, the above fall in live weight increase—but it can hardly be supposed that the plots were

* The actual references quoted from the extensive literature on the subject are indicated in the table. For a full list of references, see Somerville (26), p. 31—32.

grazed proportionately to such drastic cuttings, although it has to be remembered the sheep were kept continuously on the plots throughout the grazing season. Under more lenient cutting leaf has maintained a much more uniform productivity, in some instances it has actually been higher subsequent to June than during late April, May and June—and although it has been stated that drills probably give a somewhat exaggerated bias to leaf late in the season—even so—the seasonal leaf development and seasonal live weight increases appear on the face of it to be unduly incompatible. The chemical evidence is not sufficient to account for the great falling off in live weight increase, particularly during August and September. It is true that in May the nutritive value of leaf was on the average higher than in any other month, but the quality of the leaf in August and September was on the average certainly not less than in June.

It is obvious, however, that the ability of sheep to fatten is not only a function of the fatting properties of the herbage they are offered, thus Ashcroft (1) discussing the results at Sevington for 1909-10, states that "fly" interfered considerably with the sheep during the last month in 1910. It is probable, too, that the climatic conditions of May and June, seldom as hot as July and August, are more favourable to live weight increase, while the almost sudden change from the scarcity of April to the relative abundance of May may be expected to have a "psychological" as well as a physiological influence on grazing animals, and similarly the animal might well become satiated with a ration varying in but little except *amount* for a spell of five to six months on end, while the law of diminishing returns is not without significance in this connection.

Having regard to the above considerations, and to the fact that the manuring for mutton experiments were not designed to test seasonal productivity as such, it is hardly to have been expected that the two independent lines of enquiry would have shown obviously similar results. A good comparison of the two methods of estimating the productivity of swards could only have been made, and can only be made, by conducting stem and leaf analyses on plots differentially manured. The evidence discussed in this bulletin would seem to point to the desirability of estimating the effects of manures by a system of pasture cuts supported by stem and leaf separations, and to compare the data thus obtained with the accepted teaching of the manuring for mutton experiments.

Looked at from the point of view of maintaining the grazing areas as a whole of a farm at uniform productivity over the longest possible season, the results brought forward appear to be decidedly significant and not a little suggestive. It is interesting to note in the first place that under repeated cutting Red Clover appears to come into maximum productivity later than the grasses, and to cater admirably for July and early August—thus, if this species behaves at all similarly under grazing, a two year clover ley with a good late flowering strain predominating would seem to have a special application for this, frequently difficult, period of the year. It would also appear that the later heavy grazing is started during the season the more will be the keep available during July, August and September; and after hay it will be greater still.

Thus a just balance between the area under pasture and the area under hay is perhaps not to be arrived at by merely a cold estimate of the hay requirements of the farm, and the cost as such of handling the hay—the further question arises whether it is better to get the hay in terms of somewhat smaller crops of higher nutritive value by early cutting over a larger area, or as larger and

less nutritious crops from late cutting, with consequent considerable reduction in both the area *and yield of after-grass*, accompanied by progressive deterioration of the meadows.

In conclusion it may be stated that if the results under consideration have any bearing at all on the practice of grassland management. and a bearing they must have, can they only be correctly interpreted, they add force to the view previously expressed, namely, the desirability of managing the grassland of a farm on a rotational basis. It should be possible to aim at allocating particular fields to cater for particular seasons of the year, and to manage each field in a manner designed to bring it into productivity according to schedule. The chief application of temporary grass should be to reinforce the keep at the most critical periods of the year—the winter, March and April, and to help to maintain a high level of productivity through July and August. It is probable that a greater provision for March and April grazing by resort to special short term sowings of Italian Rye Grass in particular. by making it possible to partially rest the more permanent swards at this period would react in a striking manner on the aggregate productivity of the grasslands of farms devoted chiefly to stock rearing.

It has seemed desirable to discuss the bearing on practice of the results obtained in some little detail, and chiefly because they point so the extreme desirability of conducting large scale field trials with a view to elucidating the complicated inter-reactions between grassland and the grazing animal. In particular the old controversy as to the desirability or the reverse of setting fields aside wholly as pastures, or wholly as meadows needs to be re-opened. The merits and de-merits of each practice should be re-explored not from the point of view of experience, but from the point of view of exact experimentation, having regard to grassland type ; manurial treatment, or the lack of it ; correct or incorrect date of " putting up " to and cutting for hay ; methods of grazing adopted ; and such-like dominating factors which so fatally ballast the teachings of experience—no two " experiences" ever being the same. Exact evidence is required on the basis of live weight increase : as to whether after grass has in fact a better grazing value than pasture at equal date, and if so how much better; to what if any extent the ratio of the one to the other is influenced by date of " putting up" to and cutting for hay on the one hand. and the severity of the spring grazing on the other. Whether fields treated as pastures or as meadows in a current season provide the most abundant grazing early in the following spring. and to what extent late summer and autumn grazing, or an aftermath crop of hay as opposed to aftermath grazing influence the production of early spring keep. Until such points can be settled by exact trial, no rational rules can be laid down for the management of grassland which will continue to be the plaything of opinion and " experience."

LITERATURE CITED.

1. ASHCROFT, W.: "Experiments for ascertaining the Influence of various Manures on the Production of Mutton." *Jour. Bath and West and Southern Counties Soc.*, fourth ser. Vol. XV., 1904-5, and fifth ser., Vol. IV., 1909-10.
2. AUDAS, J. W.: The True Clovers Naturalised in Victoria." Reprint from *Jour. Department of Agri. for Victoria.* Nov., 1921.
3. BRENCHLEY, WINIFRED, and ADAM, HELEN.: "Recolonization of Cultivated Land Allowed to Revert to Natural Conditions." *Jour. Ecology*, Vol. III., No. 4. December, 1915.
4. BRUNNING, LESLIE H.: "Fodder Crops for Australia." F. H. Brunning, Ltd., Melbourne, 1922.
5. CROZIER, A. A.: "Forage Plants and Wheat." Michigan Expt. Sta., *Bul.* No. 141, 1897.
6. EIKELAND, HANS J.: "Norske straaforanalysur." *Meldinger fra Norges Landbruksoiskole*, Vol. 2, 1922, p. 237.
7. ELLET, W. B., and CARRIER, LYMAN.: "The Effect of Frequent Clipping on Total Yield and Composition of Grasses." *Jour. Amer. Soc. Agron.*, Vol. 7 (2), 1915.
8. FARROW, F. P.: "On the Ecology of the Vegetation of Breckland." *Jour. Ecology*, Vols. III. (4); IV. (2); V. (1) and VI. (2).
9. GRABER, L. F.: "On the Growth of Alfalfa with various Cutting Treatments." *Jour. Amer. Soc. Agron.*, Vol. 16 (3), March, 1924.
10. GILCHRIST, DOUGLAS A.: "Manures for Pasture." Northumberland County Agri. Expt. Sta. Cockle Park *Bul.* No. 8, 1906.
11. HALL, A. D., and RUSSELL, E. J.: "On the Causes of High Nutritive Value and Fertility of the Fatting Pastures of Romney Marsh and other Marshes in S.E. of England." *Jour. Agri. Sci.*, Vol. IV., No. 4, January, 1912.
12. HENDRICK, J.: "Report on Experiments on the Improvement of Poor Permanent Pasture." West of Scot. Coll. of Agri., *Bul.* 48 in *Ann. Report*, 1911.
13. JONES, A. E., and STAPLEDON, R. G.: "The Improvement of Upland Pastures." Univ. Coll. of Wales, Aberystwyth, Agri. Dept., *Bul.*, 1916.
14. KRAUS, C.: "Untersuchungen zu den biologischen Grundlagen des Grasbaues." *Fühlings Landw. Zeitung*, 60, Jahrgang (10) and (11), 1911.
15. LINDHARD, E.: "Om Vaeksten af Hundegraes og Draphavre ved 2 til 6 Afskaeringer i Vaekstperioden." *Tidsskr. f Landbr. Planteavl*, XIX, Kobenhavn, 1912, p. 653.
16. MAKIN, R. N.: "Fodder Crops for Dairy Farmers." *Agri. Gaz. N.S.W.*, Vol. XXXIII. (5), May, 1922.

17. McKee, Rowland.: "The Effect of Clipping on the Root Development of Alfalfa." *Jour. Amer. Soc. Agron.*, Vol. 8 (5), 1916.

18. Middleton, Sir Thomas: "The National Aspects of the Case for Increasing the Supplies of Basic Slag." *Jour. Min. of Agr.*, Vol. XXVII. (3), June, 1920.

19. ——————— "The Production of Meat on Pastures of Different Types." *ibid.*, Vol. XXIX. (4), July, 1922.

20. Osvald, Hugo: "Undersökningar öfver fodervrädet hos olika gräs fran slattervallar pa torfjord." *Svenska Mosskulturf. Tidskr.*, 1919, p. 156.

21. Pieters, A. J.: "Red Clover Culture." U.S. Department of Agri., *Farmers' Bul.*, No. 1337.

22. Rhodin, Sigurd: "Försök med vallanläggning med flere eller färre växtarter." *Centralanstalten för försoksväsendet pä Jordbruksomradet*: Meddelande, No. 204, 1920.

23. ——————— "Rön och iakttagelser frän 11 ars jämförande försök i gräs och rödklöver." *Landtbruks-Akademiens Handb. och Tidsk.*, 1923.

24. Sinclair, Sir John, Bart.: "The Code of Agriculture," p. 393. London, 1817.

25. Sinclair, George: "Hortus Gramineus Woburnensis," 2nd edition. London, 1825.

26. Somerville, William: "Manuring of Pastures for Meat and Mutton." *Min. of Agri. Mis. Pub.*, No. 30, 1921.

27. Stapledon, R. G.: "Permanent Grass." *Farm Crops*, Vol. III. (in the Press).

28. Sutton, Martin J., and Voelcker, J. A.: "Relative Feeding Value of Grass cut at different Periods of Growth." *Jour. Bath and West and Southern Counties Soc.*, Fourth ser., Vol. II., 1891-2.

29. Witte, Hernfrid: "De viktigaste vallgräsens afkastning i försök pa Svalöf aren 1910-21 samt nederbördens inflytando pa olika ars olika skörderesultat." *Sver. Utsädesf. Tidskr.*, 1922, p. 21.

30. Witte, H., and Nyström, E.: "Vallväxter för torvjordar." *Svenska Mosskulturf. Tidskr.*, 1922, p. 27.

31. Cambridge University Department Agri.: *Guide to Experiments*, 1907.

32. Welsh Plant Breeding Station, Aberystwyth: "Preliminary Investigations with Herbage Plants." *Bul.*, Series H., No. 1.

33. Messrs. James Hunter, Chester: 41*st Annual List of Agricultural Seeds*, 1923.

In order to complete the volumes the Station is anxious to obtain the following parts of the Journals and Reports indicated below.

Information leading to the acquisition of the parts required would be much appreciated.

Journal of Genetics	Vol. IV. 1914. No. 1.
Genetics	Vol. I. 1916. No. 2.
	Vol. IV. 1919. No. 1.

West of Scotland Agricultural College.
1st Annual Report (published in 1900).

The American Naturalist.
Vol. LIV. No. 635. Nov.-Dec., 1920.
Vol. LVI. No. 643. March-April, 1922.

Journal of Agricultural Research.
Vol. IV. Part 5, 1915.
Vol. VI. Part 16, 1916.
Vol. VII. All parts after 12, including index, 1916.

Sveriges Utsädesförenings Tidskrift.
Vol. 21. 1911. Part 1.
Vol. 23. 1913. Part 1.
Vol. 24. 1914. Part 2.
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